The CANADIAN FIELD-NATURALIST

Published by THE OTTAWA FIELD-NATURALISTS' CLUB, Ottawa, Canada

Volume 124, Number 1 January–March 2010

All manuscripts intended for publication except Book Reviews should be addressed to the Editor and sent by e-mail (attached) or postal mail (with disk).

Book-review correspondence should be sent by e-mail or postal mail to Roy John, Book-review Editor.

Subscriptions and Membership
Subscription rates for individuals are $33 per calendar year. Libraries and other institutions may subscribe at the rate of $50 per year (volume). The Ottawa Field-Naturalists' Club annual membership fee of $33 (individual) $35 (family) $50 (sustaining) and $500 (life) includes a subscription to *The Canadian Field-Naturalist*. All foreign subscribers and members (including USA) must add an additional $5.00 to cover postage. The club regional journal, *Trail & Landscape*, covers the Ottawa District and Local Club events. It is mailed to Ottawa area members, and available to those outside Ottawa on request. It is available to Libraries at $33 per year. Subscriptions, applications for membership, notices of changes of address, and undeliverable copies should be mailed to: The Ottawa Field-Naturalists Club, P.O. Box 35069, Westgate P.O. Ottawa, Canada K1Z 1A2. Canada Post Publications Mail Agreement number 40012317. Return Postage Guaranteed. Date of this issue: January – March 2010 (March 2011).

COVER: Mount Sedgwick, Ivvavik (North Yukon) National Park, where Bill Cody did a lot of his Yukon field work. Photographed at ~68.87529N 139.1409W facing southeast, 25 July 2008, by Bruce Bennett. See: One step at a time … A tribute to William (Bill) J. Cody, 1922-2009, pages 71-96.

THE CANADIAN
FIELD-NATURALIST

Volume 124

2010

Volume 126
The Ottawa Field-Naturalists' Club Transactions

Promoting the study and conservation
of northern biodiversity since 1880

THE OTTAWA FIELD-NATURALISTS' CLUB

OTTAWA CANADA

The Canadian Field-Naturalist

Volume 124, Number 1 January–March 2010

New Records of Vascular Plants in the Yukon Territory VIII

BRUCE A. BENNETT[1], PAUL M. CATLING[2], WILLIAM J. CODY[2], and GEORGE W. ARGUS[3]

[1] Department of Environment, Government of Yukon, Box 2703, Whitehorse, Yukon Y1A 2C6 Canada; e-mail: Bruce.Bennett@gov.yk.ca
[2] Biodiversity, National Program on Environmental Health, Agriculture and Agri-Food Canada, Wm. Saunders Building (49), Central Experimental Farm, Ottawa, Ontario K1A 0C6 Canada; e-mail: catlingp@agr.gc.ca
[3] Canadian Museum of Nature, P.O. Box 3443, Postal Station Douglas, Ottawa, Ontario K1P 6P4; e-mail: argus@sympatico.ca

Bennett, Bruce A., Paul. M. Catling, William J. Cody, and George W. Argus. 2010. New records of vascular plants in the Yukon Territory VIII. Canadian Field-Naturalist 124(1): 1–27.

Forty-seven taxa, 35 native and 12 introduced, are reported as new to the flora of Yukon and nine taxa previously reported are deleted. The new native taxa are: *Artemisia arctica* ssp. *comata, Botrychium alaskense, Botrychium minganense, Bromus richardsonii, Calamagrostis holmii, Carex incurviformis, Carex mackenziei, Carex microchaeta* ssp. *nesophila, Carex ramenskii, Carex rariflora* var. *androgyna, Carex tahoensis, Carex xerantica, Carex × flavicans, Deschampsia sukatschewii, Eleocharis erythropoda, Eleocharis macrostachya, Eleocharis mamillata, Erigeron ochroleucus, Impatiens noli-tangere, Limnorchis huronensis, Nymphaea tetragona, Polygonum douglasii* ssp. *douglasii, Potamogeton natans, Potentilla crebridens* ssp. *hemicryophila, Puccinellia tenella* ssp. *langeana, Rumex beringensis, Salix farriae, Salix glauca* ssp. *Stipuli fera, Saussurea nuda, Saxifraga hyperborea, Saxifraga rivularis* ssp. *arctolitoralis, Silene soczavana* var. *macrosperma, Symphyotrichum subspicatum, Taraxacum hyparcticum,* and *Zannichellia palustris.* The new introduced taxa are: *Acer negundo, Avena fatua, Camelina microcarpa, Crepis capillaris, Hippophae rhamnoides, Lamium amplexicaule, Linaria dalmatica, Medicago lupulina, Prunus padus, Rumex pseudonatronatus, Valeriana officinale,* and *Viola tricolor.* Deleted taxa are: *Aster laevis* var. *geyeri, Carex athrostachya, Elatine triantha, Camelina sativa, Erysimum cheiri, Galium palustre, Impatiens capensis, Platanthera hyperborea,* and *Sonchus oleraceus.* Vouchers are cited and general notes on distribution and identification are provided. Four of the native taxa reported here are new to Canada: *Botrychium alaskense, Carex microchaeta* ssp. *nesophila, Potentilla crebridens* ssp. *hemicryophila* and *Rumex beringensis.*

Key Words: Vascular plants, flora, new records, phytogeography, Ivvavik National Park, Beaufort Sea, Asi Keyi Special Management Area, Yukon Territory.

Since the writing of *New Records of Vascular Plants in the Yukon Territory VII* (Cody et al. 2005), a considerable number of additional plant specimens have been collected. Earlier collections have been reviewed, particularly herbarium collections from the University of British Columbia (UBC), University of Alberta (ALTA), Royal B.C. Museum (V) and Kluane National Park Herbarium "KNPR." None of these collections had been reviewed in the preparation of the *Flora of the Yukon Territory* (Cody 1996). The major new collection areas include the following locations (1) Yukon Arctic coast including Ivvavik National Park; (2) southern Yukon including the new Special Management areas, Asi Keyi and Agay Mene; and (3) the Peel River watershed as part of a regional planning effort.

This paper serves to further update the *Flora of the Yukon Territory* (Cody 1996) and its second edition (Cody 2000) along with other records recently published (Cody et al. 1998, 2000, 2001, 2002, 2003, 2004, 2005). The floristic information presented earlier and updated here provides the basis for biological research and ongoing work relating to wildlife management, forestry, sustainable resource management and agriculture. "Additions" are defined here as either first records or those reported elsewhere but not included in Cody (2000) or the updates listed above. With additions and deletions reported here, the flora now includes 1234 species (1349 taxa, including infraspecific entities).

The taxa addressed in the body of this paper appear in a synoptic list in alphabetical order within families which are in the same order as presented in the *Flora of the Yukon Territory* (Cody 1996, 2000). Taxa to be added to Yukon's list of rare plants (Yukon Conservation Data Centre 2009*) are indicated with a cross (†). Deletions or additions are indicated as such following the common name with an "N" for native and "I" for introduced. For each taxon, general notes are followed by a list of specimens examined and information on identification, often in the form of a key. Common names follow Cody (1996), Douglas et al. (1998-2001) and Kartesz and Meacham (1999).

Location of Specimens

Most collections reported in this paper have been deposited in the National Herbarium at Agriculture and Agri-food Canada, Ottawa (DAO). However, specimens may also be found in the following herbaria as indicated (universal acronyms from Holmgren and Holmgren 1998, with the exception of the last three which are local):

ALA – University of Alaska, Museum of the North, Fairbanks
ALTA – University of Alberta, Edmonton, Alberta
CAN – Canadian Museum of Nature, Ottawa, Ontario
ISC – Iowa State University, Ada Hayden Herbarium, Ames, Iowa
MICH – Michigan State University, Ann Arbor, Michigan
MTMG – McGill University, Montreal, Quebec
MT – Université de Montréal, Herbier Marie-Victorin, Montreal, Quebec
O – Botanical Museum, Oslo, Norway
OBI – Robert F. Hoover Herbarium, California Polytechnic State University, San Luis Obispo, California
UBC – University of British Columbia, Vancouver, British Columbia
US – Smithsonian Institution, Washington, D.C.
UTC – Utah State University, Intermountain Herbarium, Logan, Utah
V – Royal British Columbia Museum, Victoria, British Columbia
WTU – University of Washington, Burke Museum, Seattle, Washington
BABY (local acronym) – B. A. Bennett Herbarium, Whitehorse, Yukon
YG (local acronym) – Yukon Government Herbarium, Whitehorse, Yukon
KNPR (local acronym) – Kluane National Park Reserve Herbarium, Haines Junction, Yukon

Synoptic list by Yukon Status

Native taxa (N) new to Yukon: (35)

Artemisia arctica ssp. *comata*
Botrychium alaskense
Botrychium minganense
Bromus richardsonii
Calamagrostis holmii
Carex incurviformis
Carex mackenziei
Carex microchaeta ssp. *nesophila*
Carex ramenskii
Carex rariflora var. *androgyna*
Carex tahoensis
Carex xerantica
Carex × flavicans
Deschampsia sukatschewii
Eleocharis erythropoda
Eleocharis macrostachya
Eleocharis mamillata
Erigeron ochroleucus
Impatiens noli-tangere
Limnorchis huronensis
Nymphaea tetragona
Polygonum douglasii ssp. *douglasii*
Potamogeton natans
Potentilla crebridens ssp. *hemicryophila*
Puccinellia tenella ssp. *langeana*
Rumex beringensis
Salix farriae
Salix glauca ssp. *stipulifera*
Saussurea nuda
Saxifraga hyperborea
Saxifraga rivularis ssp. *arctolitoralis*
Silene soczavana var. *macrosperma*
Symphyotrichum subspicatum
Taraxacum hyparcticum
Zannichellia palustris

Introduced taxa (I) new to Yukon: (12)

Acer negundo
Avena fatua
Camelina microcarpa
Crepis capillaris
Hippophae rhamnoides
Lamium amplexicaule
Linaria dalmatica
Medicago lupulina
Prunus padus
Rumex pseudonatronatus
Valeriana officinale
Viola tricolor

Deletions (both N and I) of taxa from the Yukon flora: (9)

Aster laevis var. *geyeri*
Carex athrostachya
Elatine triantha
Camelina sativa
Erysimum cheiri
Galium palustre
Impatiens capensis
Platanthera hyperborea
Sonchus oleraceus

Taxa Accounts by Family

OPHIOGLOSSACEAE Adder's Tongue Family

†*Botrychium alaskense* Wagner & Grant, Alaskan Moonwort – (Addition – N, Canada also) Figure 1.

This species was recently described from collections made in Alaska (Wagner and Grant 2002) where it occurs in the southern third of the state including the Alaska Peninsula and the panhandle. As it occurred nearby in the Wrangell-St. Elias Mountains of Alaska it was expected to be found in Yukon (Farrar 2006*), and more collections may be found after reviewing herbarium specimens.

Specimens examined: Kluane National Park, Fisher Glacier near Alsek River, S-facing slope above Fisher Glacier, in open loose soil especially around Arctic Ground Squirrel (*Spermophilus parryii)* burrows, 40° slope dominated by *Lupinus nootkatensis*, *Artemisia norvegica* ssp. *saxatilis*. Growing with *B. pinnatum, B. lunaria* and *B. spathulatum*, 60°07'56"W 138°12'16"W, 3786', *B. A. Bennett 03-1344a*, July 8, 2003 (DAO); Haines Road, Vand Creek, in clearing that was part of the Haines pipeline, substrate 60% lichen encrusted gravel, dominant plants include *Populus* seedlings 20% Salix 10% and *Epilobium angustifolium* 5%, 60.22805°N 136.96016°W, 28 June 2007 (ISC) (Stensvold and Farrar 2008*); North Klondike Highway km 609, Clear Creek Road junction, gravel pit, growing in poorly vegetated gravels with *B. pinnatum*, 63.7543°N 137.6759°W 624 m, *G. Brunner KH16*, Photographed by G. & M. Brunner, 3 August 2007. All collections were confirmed by D. R. Farrar and M. Stensvold.

This species can be separated from similar pinnate-pinnatifid species as follows (from Farrar, 2006*):

1a. Upper pinna bases obtuse (angle > 90°) to cordate (>180°); pinna apices rounded; sporophore stalk equal to trophophore length; sporophore pinnately branched. . . . . *B. pinnatum*

1b. Upper pinna bases acute (angle < 90°); pinna apices angular; sporophore stalk shorter than trophophore length; sporophore divided into three main branches. 2

2a. Trophophore outline triangular (equilateral) with basal pinnae nearly as large as the central rachis and pinnae; pinna pairs 3-4; pinnae narrowly ovate to oblong. . . . . *B.lanceolatum*

2b. Trophophore outline narrowly triangular to broadly ovate; basal pinnae not disproportionately enlarged; pinna pairs 5-6; pinnae ovate to elliptic. . . . . *B. alaskense*

Botrychium minganense Victorin, (*B. lunaria* (L.) Sw. var. *minganense* (Vict.) Dole), Mingan Moonwort – (Addition – N)

Porsild (1951) previously reported collections of this species under the name *Botrychium lunaria* var. *minganense* from the upper Rose River valley, Mile 95, meadows along Rose River, *Porsild & Breitung #10337* (CAN) and Macmillan Pass, Yukon-Mackenzie Divide, Mile 284-290, *Porsild & Breitung #11178* (CAN). Porsild (1966) added the vicinity of Mackintosh Lodge, Mile 1022 Alaska Highway, *Porsild #7989, #7430* (CAN) and Porsild (1975) added the vicinity of Mayo on river terrace with *Potentilla anserina* #698. These records were unfortunately missed when writing the Flora of the Yukon Territory (Cody 1996). Since then, many collections of this species have come to light. *Botrychium minganense* is thus widespread throughout Yukon and should be added to the flora. The last collection cited is the most northerly collection of this species.

FIGURE 1. *Botrychium alaskense* photo credit G. Brunner.

Specimens examined: north shore of Kluane Lake near mouth of Big Arm, 61°22'N 138°43'W, *H. M. Raup & L. G. Raup*, 8 July, 1944 (CAN); Alsek River, Kluane National Park and Reserve, side of an abandoned mining road, 60°39'N 137°49'W, *P. Williston, C. Johansson & C. Wulff, 98-508*, 22 Aug 98, (UBC) (determined by W. H. Wagner); Kathleen Lake on Cottonwood Trail, *Z. Mattson, P. Caswell*, 21 June 2004 (ISC) (confirmed by electrophoresis by D. Farrar); along Donjek River, *G. W. & G. G. Douglas*, 26 June 1974 (KNPR) (identified by D. Farrar and M. Stensvold); Half Breed Creek, ca. 17 km. SSW of Burwash Landing, *L. Freese sn* (KNPR), 11 Aug. 1976; Fisher Glacier, Kluane National Park, mesic silty sand in herbaceous meadow with open soil, *B. A. Bennett 03-1041*, 7 July 2003 (ISC) (identified by D. Farrar); Nunatak near Ulu Mountain, Kluane National Park, 60°21'32"N W138°34'49"W, 5439 feet, *B. A. Bennett sn,* 6 July 2003 (ISC); Cache Lake, Kluane National Park, *L. Freese sn*, 1976 (KNPR); frequent at intervals within the Kluane Game Sanctuary on upper Copper Joe Creek 4838 feet to a point well past Cache Lake, 61°12.861'N 139°03.863'W, *L. Freese and P. Caswell* sn, 24 July 2002; Kluane National Park, trail to Duke River, 61°12.109'N 139°04.112'W, 4806 feet, *P. Caswell*

sn (ISC) (confirmed by D. Farrar); Alaska Highway, Duke River SE of bridge, in open meadow with *Anemone multifida, Helictotrichon hookeri, Achillea millefolium* and *Elymus trachycaulus* in gravelly substrate, 61°22.39N 139°08.44W, 850m, *B. A. Bennett, R. Elven & H. Solstad 03-0063*, 8 August, 2003 (DAO); Aishihik road, just before airport, north side of road along old transmission line, 962 m 61°39'16.6"N 137°29'59.1"W, *B. A. Bennett et al. 04-0127*, 20 June 2004; Asi Keyi SMA, Brooke Creek, volcanic ash slope, 61°33'34.8"N 140°49'04"W, 1495m, *B. A. Bennett & P. Seccombe-Hett 04-0903*, 22 July 2004; north of Klutlan Glacier, Asi Keyi SMA, 61°27.461'N 140°48.217'W, 5364' *P. Caswell, J. Meikle & F. Mueller 04-1023*, 23 July 2004; Richardson Mountains, tributary of Fish Creek, S of Vunta Creek, rare, only place seen, on ESE-facing upper 30° slope in shallow soil over boulders in saddle just below ridge with *Salix reticulata, Aconitum delphiniifolium, Festuca altaica, Senecio lugens, Dodecatheon frigidum* and *Parnassia kotzebuei*, 67.895°N 136.562°W, 1097 m, *B. A. Bennett & M. J. Oldham 06-284*, 3 August, 2006; South Klondike Highway, Robinson Roadhouse, NW of buildings, occasional in open field, growing in open sandy soil with *Botrychium lunaria, Sedum lanceolatum, Arenaria capillaris* and *Potentilla pensylvanica*, 60.449°N 134.847°W, 780 m, *B. A. Bennett & R. S. Mulder 06-616* (confirmed by D. Farrar and M. Stensvold) 8 July 2006 (BABY); Faro Mine site, under *Alnus crispa* ssp. *crispa* stand along dirt road near base of waste rock slope, two plants found, 62°14'57"N 133°13'29"W, 1130 m, R. Rosie W.P. 517, 11 August 2008 (BABY); Malcolm River, Locally, common at top of *Salix alaxensis/Festuca altaica* nivean meadow with lots of arctic ground squirrel diggings, growing with *Aster sibiricus, Festuca altaica, Potentilla fruticosa, Aconitum delphiniifolium, Solidago multiradiata* and *Artemisia norvegica*. 20° S-facing slope, 69.30643°N 140.4921°W, 773 m, B. A. Bennett & S. Wolfe 08-364, 22 July, 2008 (ALA, CAN).

It can be separated from similar species of *Botrychium* as follows (adapted from Farrar 2003*):

1a. Span of basal pinnae span 120° to 180°, basal side margin slightly concave; basal pinnae sessile or nearly so; pinnae not overlapping the rachis ..... *B. lunaria*
1b. Span of basal pinnae 60° to 120° **2**
2a. Pinnae spreading (nearly perpendicular to the rachis), broader than long, thin textured, margin finely toothed or crenulate, seldom deeply lobed .... *B. crenulatum*
2b. Pinnae ascending (angled toward the apex), longer than broad, firm in texture, margin entire, coarsely toothed or lobed **3**
3a. Pinnae margin entire or shallowly lobed, basal pinnae lacking sporangia; trophophore usually long-stalked; sporophore long-stalked, lax .... *B. minganense*
3b. Pinnae margin coarsely toothed, often deeply bifurcate, basal pinnae often bearing sporangia; sporophore short-stalked and stiffly upright .... *B. ascendens*

*All species occasionally produce sporangia on the lowermost pinnae

POTAMOGETONACEAE Pondweed Family

Potamogeton natans L., Floating Pondweed – (Addition – N)

This species was known from surrounding jurisdictions of British Columbia, Northwest Territories, and Alaska. Cody (1996) predicted its occurrence in southeast Yukon

Specimens examined: Labiche River, along edge of beaver pond, 60°02'41"N 123°58'30"W, *B. A. Bennett 95-244*, June 15, 1995. (DAO); Peel River Plateau, in floating mat dominated by *Carex limosa, C. canescens* and *C. aquatilis*, 66°40'39.2"N 133°54'28.9"W, *L. Schroeder and L. Randall NPE-LDS059*, July 7, 2005 (DAO).

ZANNICHELLIACEAE Horned-pondweed Family

†*Zannichellia palustris* L., Horned Pondweed – (Addition – N)

This species was included in *The Flora of the Territory* (Cody 1996) but was deleted because of a misidentification (Cody 1998, 2000). The specimens cited below are from the only three sites now known in the Territory.

Specimens examined: Cracker Creek drainage, submerged and widespread in shallow, slightly alkaline pond with *Triglochin maritima* and *Eleocharis* around the edge, 60°48'31.6"N 136°47'17.3"W, *B. A. Bennett, J. M. Line, P. Seccombe-Hett, T. McIntosh & R. Rosie 04-0101*, 18 June 2004 (DAO); Takhini Salt Flats, alkaline pond, *A. Ceska & T. McIntosh 33225*, 19 June 2004 (DAO); Peel Plateau, south of Snake River, east of junction with Peel River, washed up in shallows near shore of upland lake (NP46). Not found elsewhere along the shore, 65.908°N 133.929°W, 381 m, *R. Rosie 05-74*, 24 July 2005 (DAO).

POACEAE Grass Family

Avena fatua L., Wild Oat – (Addition – I)

Brink first reported this species as occurring in fields in Carmacks V. C. Brink sn, 20 July 1943 (UBC). It has been reported in the vicinity of Whitehorse (B. A. Bennett, personal communication 2007). Plants may have originated with imported seed from Alberta. There have been no reports of this problematic agricultural weed occurring outside cultivated fields and no evidence that it can persist, but periodic introduction is likely to continue.

Avena fatua can be separated from the more common *A. sativa* as follows (adapted from Baum 2007):

1a. Florets disarticulating at maturity, only the glumes remaining attached. Calluses bearded. Sheaths of basal leaves with scattered hairs. Spikelets 3-flowered, with 2-3 awns. .... *A. fatua*
1b. Florets not disarticulating from the glumes, remaining attached to the plant even at maturity; calluses glabrous. Sheaths of basal leaves smooth or scabridulous. Spikelets 2-flowered, with 1 awn. .... *A. sativa*

†*Bromus richardsonii* Link (*B. ciliatus* var. *richardsonii* (Link) Boivin), Richardson's Brome Grass – (Addition – N)

Pavlick (1995) illustrates the distribution of this Cordilleran species as ranging from Baja Mexico north to Yukon and Alaska. However, Pavlick & Anderton (2007) show the closest known collection to be just south of the Yukon border and do not mention any Yukon occurrence. The Douglas collections cited below are 65 km northwest of the known distribution (Saarela 2009*) and a collection from the Little Susitina Valley, north of Palmer, Alaska (Mitchell, 1967; Pavlick & Anderton, 2007) is a further 600 km west. Some other collections identified as *B. ciliatus* may be referable to *B. richardsonii*, but none were found in a review of more than 30 additional Yukon collections of *B. ciliatus* (ALA, BABY, UBC). *Bromus richardsonii* should be looked for in southern Yukon and adjacent Alaska at higher elevations.

Specimens examined: Kluane National Park and Reserve, St. Elias Lake, north shore, small meadow partially overwashed with gravel, south-facing slope of 3°, 60% vegetative coverage, moist organic soil with *Geranium erianthum*, about ten clumps present, 60°19.12'N 137°05.564'W, 2962', *P. Caswell and L. Freese PPC-2003-515,* 26 July, 2003 (ALA, DAO, KNPR Herbarium, UTC) (confirmed by J. Cayouette & M. Barkworth); Kluane National Park, Field Creek, ca 40 mi SSW of Haines Junction, 60°12'10"N, 137°38'40"W, 3700', 6 August 1974, *G. W. & G. G. Douglas 7829* (V) (determined by J. M. Saarela, 2007); Kluane National Park. Onion Lake, ca 46 mi S of Haines Junction, in subalpine meadow, 60°05'45"N, 137°25'00"W, 2800 ft, 12 August 1973, *G. W. & G. G. Douglas 7105* (CAN, V) (determined by J. M. Saarela, 2010).

Bromus richardsonii can be separated from *B. ciliatus* as follows (adapted from Saarela 2008, 2009):

1. Lemma backs glabrous or sparsely puberulent with hairs to 0.1 mm long, margins pubescent with hairs 0.5-1.3 mm long; upper glumes 6.5-9.5 mm long; lower glumes 5-7.5 mm long; anthers 0.9-1.6 mm long; basal leaf sheaths glabrous or sparsely to densely pubescent with soft and wavy hairs; upper blades with pilose adaxial surfaces; upper nodes usually pubescent. . . . . *B. ciliatus*
2. Lemma backs sparsely to densely pubescent with hairs > 0.1 mm long; upper glumes (8-)9.5-11.5(-14.5) mm long; lower glumes 7-9.5 mm long; anthers (1.2-) 1.6-2.7(-3.4) mm long; basal leaf sheaths glabrous or sparsely to densely pubescent with stiff hairs; upper blades with glabrous adaxial surfaces; upper nodes usually glabrous. . . . . *B. richardsonii*

†*Calamagrostis holmii* Lange (*C. kolymaensis* Kom.; *C. chordorrhiza* Porsild), Holm's Reed Grass – (Addition – N)

Included in *Calamagrostis stricta* ssp. *stricta* by some authors, most recently Marr et al. (2007), *C. holmii* is an Amphiberingian, almost exclusively Asian, arctic species found along the north coast of Alaska and apparently reaching its eastern limit in the vicinity of the Melville Hills, Northwest Territories (Hultén 1968: McJannet et al. 1995). In Yukon this taxon has only been found in a small area of the western extension of the Mackenzie Delta.

Specimens examined: Beaufort Sea, Blow River Delta east, in moist silty sand, slightly brackish, many dead *Alnus* in surrounding area from tidal flood of 1998, dominated by *Leymus mollis, Chrysanthemum arcticum, Calamagrostis canadensis, C. lapponica, Carex ramenskii, Puccinellia phryganodes and P. tenella* ssp. *langeana*, 68.896°N 136.961°W, 1 m, *B. A. Bennett, M. J. Oldham, C. A. Kennedy, P. Seccombe-Hett & D. C. Gordon 06-132*, 28 July, 2006 (US); Blow River Delta east, on hummocky ground amongst dead *Alnus crispa*, soil mesic silty, slightly saline with *Cochlearia groenlandica*, 68.893°N 136.961°W 3 m *B. A. Bennett, et al. 06-177*, 28 July, 2006 (CAN, US); Blow River Delta east, occasional in higher areas amongst on flood killed, *Eriophorum vaginatum* tundra with many dead *Alnus* in surrounding area from tidal flood of 1998 dominated by *Rubus chamaemorus, Ledum decumbens* and *Vaccinium vitis-idaea*, 68.894°N 136.965°W, 1 m, *B. A. Bennett, et al. 06-181*, 28 July, 2006 (US); Blow River Delta east, Outer Delta west of Whitefish Station, growing in an unusual patch of ericaceous tundra in mid delta with *Arctostaphylos alpina, Vaccinium vitis-idaea, Empetrum nigrum, Luzula confusa* and *Pedicularis labradorica*, 68.902°N 136.976°W 3 m *B. A. Bennett, et al. 06-208,* 28 July, 2006 (CAN, US); Blow River Delta, mainland sites S of E delta, tundra within 1 km of coast occasional in moist to wet *Carex* tundra meadows surrounded by *Carex aquatilis, C. chordorrhiza, C. rotundata* and *Eriophorum russeolum*, 68.868°N 136.991°W, 47 m, *B. A. Bennett, et al. 06-246*, 29 July 2006 (CAN, US); Blow River Delta east, Outer Delta west of Whitefish Station, uncommon on the delta in silty sand amongst *Oxytropis maydelliana, Empetrum nigrum, Salix fuscescens* and *Rumex arcticus*, 68.901°N 136.950°W, 3 m, *B. A. Bennett, et al. 06-185*, 28 July 2006 (US). All collections above were confirmed by P. Petersen & B. Paszko 2008. An additional collection: Arctic coastal plain near Firth River, sand dune area 69°10'N 139°20'W, *A. Rencz 285*, 17 July 1972 (ALTA) was identified by W. J. Cody.

C. holmii can be separated from *C. stricta* as follows (adapted from Hultén 1968 and Tolmachev *et al.* 1995):

1a. Longest callus hairs distinctly shorter than lemma. 2a

2a. Awn thin, straight, not twisted. 3

3a. Culms tall; glumes dull, somewhat scabrous on sides, branchlets always scabrous; panicle grayish brown. . . . . *C. stricta* ssp. *stricta*

3b. Culms shorter; glumes shiny, completely glabrous on sides, branchlets sometimes glabrous; panicle purplish-black when young. . . . . *C. holmii*

Deschampsia sukatschewii (Popl.) Roshev. (*D. borealis* (Trautv.) Roshev.; *D. caespitosa* (L.) P. Beauv. ssp. *borealis* (Trautv.) A. & D. Löve), Sukatschev's Tufted Hair Grass – (Addition – N)

Previously included in *D. caespitosa*, *D. sukatschewii* is a circumboreal species recently recognized as distinct (Barkworth 2007). It is known from a single collection near the Yukon – British Columbia border (Barkworth 2007), though it is expected to be more widespread throughout the territory. The botanical and common names are in honour of Vladimir Nikolajevich Sukatschev 1880-1967, a Russian botanist.

The two species can be separated as follows (from Barkworth 2007):

1a. Basal blades with 5-11 ribs, usually most or all ribs scabridulous or scabrous, outer ribs often more strongly so, sometimes the ribs only papillose or puberulent, usually at least some blades flat and 1-4 mm wide, the majority folded or rolled and 0.5-1 mm in diameter; lower glumes often scabridulous distally over the midvein; lower panicle branches often scabridulous or scabrous, sometimes smooth. . . . . . . *D. caespitosa*

1b. Basal blades with 3-5 ribs, ribs usually smooth or papillose, sometimes puberulent of the outer ribs scabribulous, all blades of the current year usually strong involute and hairlike, 0.3-0.5 (0.8) in diameter; lower glumes smooth over the midvein; lower panicle branches usually smooth, sometimes sparsely scabridulous. *D. sukatschewii*

Puccinellia tenella (Lange) Holmb. ssp. *langeana* (Berlin) Tzvelev (*Phippsia langeana* (Berlin) A. & D. Löve; *Puccinellia langeana* (Berlin) T.J. Sørensen ex Hultén), Tundra Alkali Grass – (Addition – N)

This is a halophytic temperate and Arctic species and is found throughout the coastal areas to the high Arctic in Canada. *Puccinellia tenella* subsp. *tenella* is found in Russia and occupies the same habitat as our subspecies (Consaul personal communication, 2006). Cody (1996) anticipated the presence of ssp. *langeana* along the Arctic coast of Yukon. This taxon is inconspicuous and easily overlooked though apparently widespread in the appropriate habitat along the coast. *Puccinellia tenella* closely resembles *Phippsia algida* in growth form, habitat and appearance but has 3-6 flowered spikelets, whereas *P. algida* has 1-flowered spikelets.

Specimens examined: Herschel Island, *Elymus/Saxifraga*/Crucifera, 69°35'N, 139°05'W, *C. A. Kennedy sn*, 22 July, 1995 (YG); Shingle Point area, mainland opposite, common on moist muddy slough right at extreme high water mark growing with *Montia fontana* and *Puccinellia phryganodes*, 69.000°N, 137.473°W, *B. A. Bennett et al*. 05-0836, 30 July, 2005 (MTMG, US); Shingle Point, common in moist mud around brackish ponds often submerged by high tides, growing with *Puccinellia phryganodes*, 68.992°N, 137.404°W, *B. A. Bennett, et al. 05-0895*, 24 July, 2005 (DAO, MTMG); Ivvavik National Park, Clarence Lagoon, common in brackish marsh, forming large mats with *Hippuris tetraphylla* and *Carex glareosa*, 69.619°N, 140.767°W *B. A. Bennett, et al. 05-1087*, 7 August 2005 (DAO, MTMG); Blow River Delta east, locally common but only found growing at two sites in moist silty sand, slightly brackish, many dead *Alnus* in surrounding area from tidal flood of 1998, dominated by *Leymus mollis, Chrysanthemum arcticum, Calamagrostis canadensis, C. lapponica, Carex ramenskii* and *Puccinellia phryganodes*, 68.89552, 136.96149, 1m, *B. A. Bennett, M. J. Oldham, C. A. Kennedy, P. Seccombe-Hett & D. C. Gordon 06-131*, July 28, 2006 (ALA, CAN, DAO, US); Ivvavik National Park, Malcolm River, barrier beach at mouth of, common on beach sand on ocean side of lagoon with *Artemisia arctica* ssp. *comata, Mertensia maritima, Honckenya peploides, Festuca baffinensis* and *Papaver lapponica*, 69°36.845'N 139°55.512'W, 5', *B. A. Bennett, C. L. Parker, T. McIntosh, P. Seccombe-Hett and M. Joe 05-0686b*, August 5, 2005 (MTMG); Northern Yukon (Ivvavik) National Park, Stokes Point, saline marshland, periodically flooded, with *Carex maritima, Eriophorum*, vetches, 69°20'N, 138°44'W, *L. L. Consaul and S. G. Aiken 1009*, 11 July 1990 (CAN). All collections were confirmed by L. Consaul.

CYPERACEAE Sedge Family

Carex athrostachya Olney, Slender-Beak Sedge – (Deletion – N)

First reported by Porsild (1975) in the vicinity of Mayo it was added to *The Rare Vascular Plants of the Yukon* (Douglas 1981); however, the collection was not reviewed at that time. Cody et al. (2004) reported a second collection. Both collections have since been revised to *C. crawfordii* by A. A. Reznicek (MICH). This species should therefore be removed from the Yukon flora.

Carex athrostachya may be separated from *C. crawfordii* as follows (adapted from Mastrogiuseppe, et al. 2002):

1a. Proximal 2-3 inflorescence bracts leaf-like, much longer than the inflorescence and more of less surrounding the culm. . . . .*C. athrostachya*

1b. Proximal 2-3 inflorescence bracts bristle-like, often with a bristle tip shorter or equaling the inflorescence. . . . .*C. crawfordii*

†*Carex incurviformis* Mackenzie var. *incurviformis* (*C. maritima* Gunn. var. *incurviformis* (Mackenzie) Boivin), Curved-spiked Sedge – (Addition – N)

"*Carex incurviformis* is an alpine member of the *C. maritima* complex, and seems clearly (though subtly) distinct from the widespread and variable *C. maritima* which in North America is a lowland and mostly coastal species" (Reznicek 2002). *Carex incurviformis* was unfortunately missed both from Cody (1996, 2000). The species was included in Flora of North America (2002), but the Yukon was omitted from the distribution statement and map.

Specimens examined: Kaskawulsh nunatak, jct. N and central arms Kaskawulsh Glacier, dry, exposed slope, 6000 ft., *D. F. and B. M. Murray 1081*, July 24-27, 1967 (ALA); Steele Glacier and vicinity, moist sheltered valley, above 6000 ft., *D. F. and B. M. Murray 1344*, August 5-10, 1967 (ALA); King Peak above Quintino Sella Glacier, south facing granitic rock at end of spur ridge, 9200-9400 ft., *V. Hoeman sn*, July 29, 1967 (ALA); vicinity of Rusty Glacier terminus, neoglacial moraine, 61°16'N, 140°15'W, *D. F. Murray 1336*, August 6, 1967 & *D. F. Murray 1788*, July 15, 1968 (ALA); Asi Keyi SMA, north of Klutlan Glacier, uncommon in wet flat alpine tundra 90% vegetated with *Carex microglochin* and *Salix arctica*, 61°27.545'N, 140°48.017'W, 5418', *P. Caswell, J. Meikle & F. Mueller 04-1033*, July 23, 2004 (DAO).

Carex incurviformis can be separated from *C. maritima* as follows (adapted from Reznicek 2002):

1a. Perigynia finely veined to nearly veinless abaxially, essentially veinless adaxially, ovate to broadly ovate, (1.4-) 1.6 -2.3 (-2.7) mm wide; pistillate scales with usually broad whitish hyaline margins, broadly ovate to orbicular, apex obtuse to ± acute; arctic and subarctic lowlands. . . . . *C. maritima*

1b. Perigynia finely veined on both surfaces, elliptic, 1-1.5(-1.6) mm wide; pistillate scales with very narrow whitish hyaline margins, ovate, apex acute to acuminate; alpine zone of the Rocky Mountains. . . . . *C. incurviformis*

†*Carex mackenziei* Krecz., Mackenzie's Sedge – (Addition – N)

This species was previously reported from Yukon (Toivonen 2002) but without reference to specific locations and vouchers. It was found to be locally abundant though limited in distribution,

Specimens examined: Beaufort Sea, Lower Blow River Delta, dry gravel sandspit dominated by *Elymus arenarius*, *Lathyrus japonicus* and graminoides. 30% cover, 69°56'N 137°11'W *L. Dickson 5287*, 8 July 1982 (DAO) originally identified as *C. marina* (*C. amblyorhyncha*) from which it differs by having 3-10 spikes, whereas *C. marina* has 2-3 (4) spikes. (determined by J. Cayouette); Blow River delta, extreme western edge, locally common but only place seen on the survey of the Yukon coast, codominant in brackish marsh behind logs growing with *Carex aquatilis* ssp. *stans*, *Dupontia fisheri*, *Arctophila fulva*, *Hippuris tetraphylla* and *Alopecurus alpinus*, 68.929°N 137.090°W, 2', *B. A. Bennett 05-0930*, 28 July 2005 (ALA, DAO, UBC); east of the Blow River on the outer delta to the Northwest Territories border, 2006, common and widespread codominant, 68.896°N 136.961°W, *B. A. Bennett, M. J. Oldham, C. A. Kennedy, P. Seccombe-Hett & D. C. Gordon 06-130, 06-191, 06-300, 06-318, 06-340, 06-346*, 28 July 2006 (ALA, ALTA, CAN, DAO, MICH, WTU) (confirmed by J. Cayouette).

C. mackenziei can be separated from other members of this group by its terminal spike clearly being clavate and staminate for at least ½ its length; also its pistillate scales are equal or exceeding the perigynia and partly concealing them.

Carex microchaeta T. Holm ssp. *nesophila* (Holm) D. F. Murray, (*C. nesophila* T. Holm), Alpine Tundra Sedge – (Addition – N, Canada also)

This species has a Beringian in distribution and is known from Alaska and the Russian Far East. It was reported in Taylor and MacBryde (1977) as occurring in British Columbia and in the Richardson Mountains, Northwest Territories by Porsild (1943); however, neither report is mentioned in Murray (1970, 2002). It has been expected in Yukon as it is known from several sites adjacent to the Yukon/Alaska border, and it may be more widespread especially in western and northern Yukon.

Specimens examined: Asi Keyi SMA, volcanic ash areas north of Brooke Creek, locally common in open areas amongst shrubs and along stream in wet heath shrub tundra, 61°34'08.6"N 140°49'42.7"W, 1504m, *B. A. Bennett, K. Kuba & P. Seccombe-Hett 04-1012*, 24 July 2004 (DAO); Asi Keyi SMA, Kluane Range, mountain NW of Sergerent Creek, in south-facing seepage slope in heath tundra growing with *Carex misandra* and *Carex podocarpa*, 61°41'54.4"N 140°20'10.2"W, 1843 m, *B. A. Bennett & P. Seccombe-Hett 04-1127,* 26 July 2004 (ALA); Asi Keyi SMA, Kluane Range, mountain NW of Sergerent Creek, commonly growing in rock and boulder pavement in organic soil at mountain summit granite bedrock, 20% vegetation cover, E-facing 5° slope, 61°42'32.5"N 140°19'21.3"W, 2186m, *B. A. Bennett & P. Seccombe-Hett 04-1145*, 26 July 2004 (DAO). Specimens were confirmed by C. L. Parker (ALA).

The two subspecies can be separated as follows (from Murray 2002):

1a. Perigynia, including beak, reddish brown or purple; midvein of pistillate scales dark, same colour as body, inconspicuous. . . . . *Carex microchaeta* ssp. *microchaeta*

1b. Perigynia, greenish yellow or yellow-brown, beak black; midvein of pistillate scales lighter colour than body, conspicuous. . . . . *Carex microchaeta* ssp. *nesophila*

Carex ramenskii Komarov, Ramens's Sedge – (Addition – N)

Standley et al. (2002) wrote, "*Carex ramenskii* seems to be the northwestern counterpart of *C. salina* and is thought to be a stabilized hybrid of *C. lyngbyei* and *C. subspathacea*. It has not been reported outside of the common range of the two putative parents. Plants identified as *C. ramenskii* from Alaska and Northwest Territories attributed to *C. ramenskii* are mostly *C. subspathacea*." The collections listed above are well beyond the range of *C. lyngbyei* yet match the collections from southern Alaska. Though *C. subspathacea* appears to be more common throughout

the Yukon Arctic coast, and populations of *C. ramenskii* are mixed throughout; it is difficult at this time to assess the status of this species.

Specimens examined: Shingle Point, drinking hole on mainland, common forming nearly pure stands at south end of bay in shallow water with *Dupontia fisheri* and *Carex subspathacea*, lots of driftwood debris, 68.970°N 137.373°W, 12', *B. A. Bennett, T. McIntosh, J. Line, J. Staniforth and D.C. Gordon 05-1033*, 29 July 2005 (ALA, DAO, MICH); Kay Point, common to abundant forming meadows on brackish flats, 69.287°N 138.366°W, 2', *B. A. Bennett & T. McIntosh 05-1183*, 1 August 2005 (CAN, MICH); common on meadows on delta, occasionally flooded by brackish water dominated by *Palustriella falcata, Potentilla egedii, Puccinellia phryganodes, P. vaginata, Triglochin maritima, Carex ursina, Salix ovalifolia* and *Calamagrostis deschampsioides*. Blow River Delta east, "Bill Storr Channel" 68.863°N 136.802°W 1 m *B. A. Bennett, M. J. Oldham, C. A. Kennedy, P. Seccombe-Hett & D. C. Gordon 06-345* 31 July, 2006 (MICH). All specimens were identified by A. A. Reznicek.

C. ramenskii can be separated from *C. subspathacea* as follows (adapted from Standley et al. 2002):

1a. Leaves involute, 1-2 mm wide, plants small 3-15 cm tall. . . . . *C. subspathacea*
1b. Leaves v-shaped, greater than 2 mm wide, plants 10-50 cm. . . . . *C. ramenskii*

†*Carex rariflora* (Wahlenb.) Sm. var. *androgyna* Porsild, Loose-flowered Alpine Sedge – (Addition – N)

This variety was first described from Atkinson Point, Northwest Territories (Porsild 1943) and as an endemic to the Arctic coast just east of the Mackenzie River in the N.W.T. (Porsild and Cody, 1980). Variety *rariflora* was found to be common, widespread and often dominant, however variety *androgyna* is rare and was seen only in a few spots. Variety *androgyna* is more robust and flowers later after most plants of variety *rariflora* have senesced. The existence of this apparently Canadian endemic was not discussed in the *Flora of North America* treatment of this group (Ball 2002).

Specimens examined: Blow River Delta, near Whitefish Station, occasional in boggy poorly drained overgrown back channels, slightly brackish, with many dead *Alnus* in surrounding area from tidal flood of 1998; often growing with *Carex mackenziei, C. aquatilis, Ranunculus pallasii, Eriophorum angustifolium, Dupontia fisheri* and *Arctophila fulva* in moss. 68.894°N 136.965°W, *B. A. Bennett, M. J. Oldham, C. A. Kennedy, P. Seccombe-Hett & D. C. Gordon 06-174*, 28 July 2006 (CAN, DAO).

It can be separated from variety *rariflora* as follows (adapted from Porsild & Cody, 1980):

1a. Terminal spike mainly staminate, occasionally a few pistillate flowers may be present at the base. Pistillate flowers with 3 stigmas. . . . . var. *rariflora*
1b. Terminal spike mainly pistillate, with a few staminate flowers present at the summit. Pistillate flowers with 2 stigmas. . . . . var. *androgyna*

Carex tahoensis Smiley Lake, Tahoe Sedge – (Addition – N)

"*Carex tahoensis* resembles *C. phaeocephala* somewhat but often occurs at lower elevation, has longer achenes, and more coriaceous perigynia that are clearly veined adaxially. *Carex tahoensis* was originally described as a Californian endemic, but is much more widespread. The precise distribution is as yet unclear because of confusion with *C. phaeocephala* and *C. petasata*. Many reports of *C. xerantica* from the Rocky Mountain region are based on this species." (Mastrogiuseppe et al. 2002). *Carex tahoensis* is apparently widespread in the low elevation grasslands of southwest Yukon.

Specimens examined: Carcross Dunes, just beyond unstable dunes in moraine, 60°10.113'N, 134°42.983'W, 663m, *B. A. Bennett, C. L. Parker, R. Rosie and R. S. Mulder 98-636*, August 29, 1998 (DAO, MICH); Carcross Dunes, slope 15°, exposure south, silt over bedrock with *Calamagrostis purpurascens, Stipa nelsonii, Achillea millefolium, Antennaria rosea, Arctostaphylos uva-ursi, Erigeron compositus, Pulsatilla patens, Potentilla arguta*, 60°10'59"N, 134°43'47"W, 2242', *B. A. Bennett & R. S. Mulder 03-1326*, August 17, 2003 (DAO, MICH); Carcross, dunes and NE shore of Lake Bennett, bedrock knoll among dunes, dry *Artemisia*-graminoid slope, scattered, 60.1667°N, -134.700°W, *C. L. Parker & B. A. Bennett 8286*, August 30, 1998, (ALA); Mtns. about 11 km E of Little Atlin Lake, N of road, rocky soil below timberline, 60.367°N, 133.850°N, *Raup & Correll 11270*, August 13, 1943 (ALA); Snafu Lake, slope behind campground, accuracy 7m, slope 28°, SSE-facing, east of ATV track, silty soil with gravels and cobbles with *Potentilla arguta, Stipa richardsonii, Amelanchier alnifolia, Pulsatilla patens, Saxifraga tricuspidata, Cerastium arvense, Sedum lanceolatum, Achillea millefolium, Penstemon procerus*, 60°08'08.6"N, 133°48'22"W, 791m, *B. A. Bennett, R.S. & P. Mulder 04-0045*, May 23, 2004 (MICH); Snafu Lake, slope behind campground, commonly growing in dry to xeric conditions along eskers and south-facing slopes, 60°08'08.6"N, 133°48'22"W, 790m, *B. A. Bennett, A. & O. Ceska , R. Rosie & P. Seccombe-Hett 04-0287*, June 28, 2004, (DAO, MICH); Mile 13 Dawson Road (from Alaska Hwy.), E of Lake Laberge, occasional in runnel on open grassy SW-facing slope, 60.983°N, 135.167°W, 640 m, *J. A. Calder & I. Kukkonen 27995*, August 9, 1960 (ALA); Sideslip Lake, south-facing extremely steep dry meadow above lake 63°09'N 135°24'W, 1219 m, *C. E. Kennedy sn*, 25 July, 1987 (YG); vicinity of Pine Creek near mile 1019 Alaska

Hwy., prairie, 60.783°N, 137.583°W, *Raup & Raup 11761*, June 16, 1944 (ALA); Alsek River valley ca. 1.6 km E of Haines Road Jct., prairie, among willows, 60.767°N, 137.500°W, *Raup & Raup 11958*, June 26, 1944 (ALA); Bridge River-Tatshenshini River confluence, in *Betula glandulosa-Festuca altaica* meadow, slope 0%, 60.00°N, 137.217°W, 550 m, August 9, 1975 (ALA); Kluane National Park, Mile 154 Haines Highway ca 900' S of highway in *Betula / Festuca* stand S35W slope 3%, 2600', *G. W. Douglas & G. G. Douglas 6575*, 30 July 1973 (V); Blanchard River (Mile 66 from Haines Junction), rare in grassy-gravelly area near river bank and roadside, 59.98°N, 136.83°W, *J. A. Calder & I. Kukkonen 28177*, August 12, 1960 (ALA); Kluane National Park, Bates Lake, ca 1.5 km W of, in *Festuca altaica* community, slope 0%, 60°11'00"N 137°39'00"W, 720 m, *H. L. Weaver & I. J. Weaver 55*, July 4, 1975 (V); Alaska Highway Mile 1018, along roadside, on edge of *Populus tremuloides* stand, 60°46'00"N 137°33'00"W, 745 m, *G. W. Douglas & G. G. Douglas 9133*, August 6, 1975 (V); Kluane National Park, Bridge River and Tatshenshini River; junction of two rivers, in *Betula glandulosa-Festuca altaica* meadow, slope 0%, 60°00'00"N 137°13'00"W, 550 m, *G. W. Douglas & G. G. Douglas 9147*, August 9, 1975 (V); Kluane National Park, Onion Lake, ca 46 miles S of Haines Junction, in subalpine meadow, 60°05'45"N 137°25'00"W, 2800 ft., *G. W. Douglas & G. G. Douglas 7098*, August 12, 1973 (V). All specimens were identified or confirmed by A. A. Reznicek).

In Yukon *C. tahoensis* has also been confused with *C. macloviana* and *C. praticola* from which is can be separated as follows (adapted from Mastrogiuseppe et al. 2002):

Plants densely cespitose. Perigynia conspicuously veined adaxially, at least 3 veins longer than achene. Pistillate scales uniformly as long as or longer than mature perigynia, usually concealing the beaks which are cylindrical, unwinged, and more or less entire for 0.4 mm or more from apex, and hyaline tipped; pistillate scales white hyaline margined; inflorescences stiffly erect.

1a. Larger perigynia 6-8 mm long; inflorescence open. . . . . *C. petasata*
1b. Larger perigynia less than 3.8-6 mm long; inflorescence dense to ± open. 2
2a. Pistillate scales margin white-hyaline 0.1-0.3 mm wide, perigynia conspicuously (0-) 4-9 veined abaxially, conspicuously 0 (-4) veined adaxially. . . . . *C. phaeocephala*
2b. Pistillate scales margin white-hyaline 0.2-0.6 mm wide, perigynia conspicuously 7-14 veined abaxially, conspicuously 3-8 veined adaxially. . . . *C. tahoensis*

C. tahoensis is apparently relatively widespread in south central and southwestern Yukon as far north as 63°N. It is found mainly on open rocky or gravelly south-facing low elevation slopes. Mastrogiuseppe *et al.* (2002) remark, "Reports of *Carex phaeocephala* from northern Canada are based on other species, mostly *C. tahoensis*.", and thus exclude *C. phaeocephala* from Yukon in their distribution maps. However, this statement is in error. Though several collections of *C. phaeocephala* examined by A. A. Reznicek were revised, many retained their original identification and thus *C. phaeocephala* remains a rare element of the Yukon flora and should continue being listed as such (Yukon Conservation Data Centre 2009*).

†*Carex xerantica* Bailey, White-Scale Sedge – (Addition – N)

According to (Mastrogiuseppe et al. 2002, page 358) "*Carex xerantica* is a rather local northern species of the Great Plains which has a distinctive pale silvery aspect to the inflorescences." It has now been found and collected on dry grass slopes above Marcella Lake, Carcross-Atlin Road; close to British Columbia border. 60°10'N 134°42'W, *A. Ceska, O. Ceska & T. Goward 11961*, 8 July 1982. (V187548 – photocopy DAO) (identified by A. Ceska, confirmed by A. A. Reznicek)

To the south it is known in northeastern British Columbia (Douglas et al. 2002); an extension of 835 km to the NW. Additional collections of this species from Alaska and the Northwest Territories are housed at ALA.

Carex xerantica has been confused with *C. tahoensis* and *C. petasata* but can be separated as follows (A. A. Reznicek, personal communication, 2005):

1a. Pistillate scales reddish brown; perigynia 4.5 × 6 × 1.5-2.6 mm; distinctly veined adaxially. . . . . *C. tahoensis*
1b. Pistillate scales whitish to yellowish; 3.8 -4.8 × 1.4 -2.2 mm; veinless or indistinctly veined adaxially. . . . . *C. xerantica*

Carex × *flavicans* (Nylander) Nylander (=*C. subspathacea* Wormsk. × *C. aquatilis* Wahlenb.) – (Addition – N)

"*C.* × *flavicans* is known from various regions: James Bay in Ontario, Hudson Bay in Manitoba, Southampton Island, Devon Island, and Baffin Island." (Cayouette and Catling 1992). Cayouette (in press) writes "*Carex* × *flavicans* seems to replace *C. salina* beyond its northern limit and represents most of the plants considered by Polunin as "*C. salina* transitional to *C. aquatilis* var. *stans*" (Polunin, 1940). This hybrid is not only widespread, but frequently forms extensive populations in coast ponds in the Churchill area."

The region of the eastern Blow River delta to the mouth of the Mackenzie River is a complex combination of many of the arctic members of the *Carex* section *Phacocytis*. *Carex subspathacea*, *C. aquatilis*, and *C. ramenskii* grow in meadows in a complex mix. This hybrid was not observed elsewhere on the Yukon coast; however, it likely occurs where the two parent species grow together; both are widespread.

Specimens examined: Beaufort Sea, Blow River Delta east, locally common in moist silty sand, slightly brackish, many dead *Alnus* in surrounding area from tidal flood of 1998; dominated by *Leymus mollis, Chrysanthemum arcticum, Calamagrostis canadensis, C. lapponica, Carex ramenskii, Puccinellia phryganodes* and *P .tenella* ssp. *langeana*, 68.896°N 136.961°W, 1 m, *B. A. Bennett, M. J. Oldham, C. A. Kennedy, P. Seccombe-Hett & D. C. Gordon 06-120*, 28 July, 2006 (ALA, DAO, MICH) (identified by A. A. Reznicek, confirmed by J. Cayouette); Peel/Blow River Delta, Fish River, uncommon and patchy in low lying area surrounded by tundra, 68.861°N 136.812°W, 2 m, *B. A. Bennett, et al. 06-341*, 31 July 2006 (DAO, MICH)) (identified by A. A. Reznicek, confirmed by J. Cayouette); Blow River Delta east, Whitefish Station, outer delta, common to abundant invading tundra ponds growing with *Carex aquatilis, C. mackenziei* and *Hippuris tetraphylla*, 68.888°N 136.894°W, 3 m, *B. A. Bennett, et al. 06-302b*, 30 July 2006 (DAO, MICH) (identified by A. A. Reznicek); Blow River Delta east, Whitefish Station, outer delta, dominant forming nearly pure stands in moist meadows. Highly variable at times resembling *C. ramenskii* and grading into *C. aquatilis* ranging from under 6" in height to over 14", 68.891°N 136.911°W, 1 m, *B. A. Bennett, et al. 06-309*, July 30, 2006 (DAO, MICH) (identified by A. A. Reznicek).

†*Eleocharis erythropoda* Steud., Bald Spike-rush – (Addition – N)

This species was known from the surrounding jurisdictions of British Columbia, Northwest Teritories, and Alaska (Smith et al. 2002) and so was expected to occur in Yukon

Specimen examined: Liard River approximately 20 km NW of Watson Lake, on sand bar, 60.152°N 129.020°W, 616 m, *G. E. Hutchings sn*, 9 August 2004 (CAN) (Confirmed by J. Sarrela)

Eleocharis macrostachya Britt., Pale Spike-rush – (Addition – N)

This taxon was reported as occurring in the territory (Smith et al. 2002) and as it is close in appearance to *E. palustris* and *E. mamillata* it may be overlooked.

Specimens examined: Alaska Highway, vicinity of Mackintosh, mile 1022, damp open alkaline meadow in spruce woodland forming large patches in moist depressions, *W. B. Schofield & H. A. Crum 8173*, 4 August 1957 (UBC V115635) (identified by S. G. Smith, 1999 as part of the Flora of North America Project); Alaska Highway, Sulphur Lake, mile 1038, pond margin, *W. B. Schofield & H. A. Crum 8027* 28 July 1957 (CAN) (identified by J. Sarrela).

Eleocharis mamillata (Lindb.) Lindb., Soft-stem Spike-rush – (Addition – N)

This taxon was reported as occurring in the territory (Smith et al. 2002) although these are the first collections to be reported.

Specimens examined: Near Dawson City, Hunker Creek near Independence Creek, old dredge pond, *D. J. Campbell 142*, 13 August 1951 (MT) (identified by S. G. Smith); Aishihik Road, east of, near Decourcy Lake, commonly growing in *Drepanocladus* mats with *Senecio congestus, Stellaria crassifolia* in wet marly soil at edge of lakes in deep humus, 3247' 61.423°N 137.025°W, *B. A. Bennett, B. Smith, L. Schroeder, A. & O. Ceska , R. Rosie & P. Seccombe-Hett 04-0198*, 23 June 2004 (CAN) (confirmed by J. Saarela); Lower Labiche valley, along western edge of pond with *Juncus alpinoarticulatus*, 60.044°N 123.970°W, 397 m., *B. A. Bennett& L. Schroeder 04-0712*, 14 July 2004 (DAO).

Eleocharis palustris is very difficult to separate from *E. mamillata* and *E. macrostachya*. Specimens require mature achenes and a large collection is recommended to capture the variation within a population. More work is required to assess the status of this complex in Yukon. The three new species of *Eleocharis* reported here can be separated from the more common *E. palustris* as follows (adapted from Alaska *Eleocharis* key A. A. Reznicek 2003*):

1a. Lowest scale of spikelet clasping at least ¾ of the diameter of the culm
2a. Lowest scale of spikelet consistently clasping the entire stem, only one sterile basal scale present. . . . . *E. erythropoda*
2b. Lowest scale of some or all spikelets clasping less than the entire stem; 2 sterile scales present in some spikelets. . . . . *E. macrostachya*
1b. Lowest scale of spikelet clasping only about 2/3 of the diameter of the culm
3a. Perianth bristles absent or up to 4 (-5), usually shorter than achenes (tubercles included); achene apex with or without distinct neck, tubercles often not sessile on achenes, culm subterete and firm. . . . .*E. palustris*
3b. Perianth bristles absent or up to (-4) 5-6 (-8), longer than achenes (tubercles included); achene apex without distinct neck, tubercles sessile on achenes, culms very soft and flat or compressed. . . . . *E. mamillata*

ORCHIDACEAE Orchid Family

Limnorchis huronensis (Nutt.) Rebrist. & Elven (*Orchis huronensis* Nutt., *Platanthera huronensis* (Nutt.) Lindl.), Lake Huron Green Orchid – (Addition – N)

Some of the Yukon plants previously referred to as *Platanthera* (*Limnorchis*) *hyperborea*, are now correctly placed with *Platanthera* (*Limnorchis*) *aquilonis* (Sheviak 1999, 2002; Cody et al 2001) and others are in fact correctly referred to *Platanthera* (*Limnorchis*) *huronensis*. A number of recent collections are also referred to the latter. *Platanthera huronensis* was previously known from southeastern Alaska and northeastern BC adjacent to the Yukon border (Sheviak, 2002). In 2008, this group of orchids was found to be peripheral to the main group of *Platanthera* spp.

(Elven and Murray 2008a) and thus *Limnorchis* proposed by Rydberg (1900) has been accepted as different from *Platanthera*.

Specimens examined: Labiche River, edge of old gravel pit with beaver lodge surrounded by *Picea mariana* forest SE of bridge, 60°03'N 124°00'W *B. A. Bennett 97-311*, 25 June 1997 (BABY); very robust form in meadow downstream of beaver pond where rare, Larsen Hot Springs Lower Pool, 60°12'N 125°32'W, *B. A. Bennett 98-335*, 14 August, 1998 (DAO); "Ottertail Creek", west of Mt. Martin, occasional amongst *Salix* in *Carex* fen, 60°07'00"N 124°15'20"W, *B. A. Bennett 98-257*, 16 June 1998 (DAO); Coal River, wetland-*Larix/Betula/Salix*, 60°08'N 127°25'W. *C. E. Kennedy #28*, 6 July 1983 (YG 1026); Whitehorse, east of Copper Haul Road, marl concretions – *Menyanthes* 20% shrub birch, 60°43'N 135°09'W *C. E. Kennedy #40* 9, July 1996 (YG 3259); Hotspring Creek, hot springs area, large forb meadow, 63°04'N 135°41'W *B. Gallagher #663*, 7 August 1987 (YG 2413); Jackfish Lake, pond with large graminoid fen, 66°49'N 133°49'W *G. Brunner #51a-99*, 9 July 1996 (YG 4959). The Kennedy, Gallagher and Brunner collections bear the note "*P. huronensis* s.l. autogamous northern race, perhaps aff. *P. hyperborea*" (determinations by C. J. Sheviak). Undoubtedly there are many more than these that require re-identification.

These two species may be separated as follows: (adapted from Sheviak, personal communication 2006)

1a. Flowers whitish green; lip slenderly lance-acuminate, the base often rounded-dilated; anther high with anther sacs only somewhat diverging toward oblong viscidia; pollinia retained within the anther sacs and flowers not autopollinating. .... *L. huronensis*

1b. Flowers green with dull yellowish lip; lip rhombic-lanceolate, not rounded-dilated at the base; anther low with the anther sacs very widely diverging toward orbicular viscidia; flowers autopollinating with whole pollinia falling out on the stigma or the massulae dissociating and spilling out of the anther sacs. .... *L. aquilonis*

FIGURE 2. *Salix farriae* illustration by J. R. Janish courtesy of the University of the Washington Press.

SACEAEALIC

†*Salix farriae* Ball (*Salix hastata* L. var. *farriae* (Ball) Hultén), Farr's Willow – (Addition – N). Figure 2.

This is a cordilleran species ranging from Wyoming to central British Columbia with disjunct occurrences in southern Yukon, western Northwest Territories, and northwestern British Columbia. It is related to *S. hastata*, an amphiberingian species ranging from Scandinavia to southwestern Yukon and northwestern Northwest Territories.

Specimens examined: Rose-Lapie River Pass slopes east of mile 105 Canol Road, elevation 6000' *A. E. Porsild & A. J. Breitung No. 10887* 1944 (CAN) originally identified as *S. barclayi*; Canol Road mile 77 east slope of Rose River valley, forming thickets by a stream, *A. E. Porsild & A. J. Breitung No.10276* 1944 (CAN) originally identified as *S. barclayi*; uncommon shrub three feet tall at edge of *Salix planifolia* fen and *Pinus contorta* forest. Mile 635, Alaska Highway Watson Lake 60°03'N 128°40'W *G. W. Argus & W. Chunys 5055 26 June, 1966* (CAN); Mile 174 Campbell Hwy. growing 1.5 m tall with *S. bebbiana*, 61°04'N 131°25'W *R. D. Dorn 1641*, 8 July, 1972 (CAN) originally identified as *S. barclayi*; Spencer Creek, 35 miles west of Watson Lake (Note: "35 miles" on original specimen label is a typographical error), common on burned till ridges, *J. S. Rowe 7304*, 20 June 1973 (CAN) originally identified as *S. barclayi*; Labiche Range, occasional low growing 1 m or less, in rich lush herbaceous meadow south-facing 30° slope with *Festuca altaica, Epilobium angustifolium, Artemisia norvegica* ssp. *saxatilis, Mertensia paniculata, Phleum alpinum, Vaccinium caespitosum,*

60.441°N 124.436°W, 1403m, *B. A. Bennett & P. Seccombe-Hett 04-0672*, 14 July, 2004 (CAN, DAO); Crow River Hot Springs, moist hot spring meadows dominated by *Solidago canadensis, Castilleja miniata* and *Geranium richardsonii*, 60.441°N 124.436°W, 1403m, *B. A. Bennett & P. Seccombe-Hett 04-0735*, 16 July, 2004, originally identified as *Salix prolixa* (CAN). All specimens were identified by G. W. Argus.

Salix farriae is often confused with *S. barclayi* and is closely related to S. *hastata*. The following comparison may help to distinguish them:

1a. Juvenile leaves glabrous, pilose, or moderately densely villous; largest medial leaf blades oblong, narrowly elliptic, elliptic, oblanceolate, or obovate, margins always toothed; pistillate flowering branchlets 4-24 mm; staminate flowering branchlets 0-17 mm; floral bracts brown to black, moderately densely hairy; anthers 0.6-1 mm styles 0.6-2.5 mm; stipes 0.4-1.5 mm. . . . . *Salix barclayi*

1b. Juvenile leaves glabrous or sparsely villous; largest medial leaf blades narrowly elliptic to elliptic, margins generally entire; pistillate flowering branchlets 1.5-14 mm; staminate flowering branchlets 1-5 mm; floral bracts bicolored, brown or black, sparsely hairy; anthers 0.3-0.6 mm styles 0.3-1.2 mm; stipes 0.5-1.2 mm. . . . . *Salix farriae*

1c. Juvenile leaves sparsely pubescent; largest medial leaf blades narrowly to broadly elliptic, narrowly ovate, or ovate, margins generally entire; pistillate flowering branchlets 1.5-9 mm; staminate flowering branchlets 1-7 mm; floral bracts brown or bicolored, sparsely hairy; anthers 0.4-0.6 mm; styles 0.2-0.48 mm; stipes 0.4-1.2 mm. . . . . *Salix hastata*:

Salix glauca L. ssp. *stipulifera* (Floderus ex Hayren) Hiitonen (*Salix stipulifera* Floderus ex Hayren, Mem.; *S. glauca* var. *stipulata* Floderus), Blue-green Willow, Gray Willow – (Addition – N)

This subspecies was known from Alaska and northern Northwest Territories and was expected to occur in northern Yukon; however, these are the first confirmed collections of this subspecies.

Specimens examined: Shingle Point area, mainland opposite herbaceous slopes above beaches at Arctic Ocean, 68.985°N 137.420°W 25' *B. A. Bennett, T. McIntosh, J. Line, J. Staniforth and D.C. Gordon 05-0981b*, 25 July 2005 (CAN); Blow River Delta, mainland sites S of E delta, shale cliffs near Coney Lake common on edge of tundra and along shale cliffs along shore with *Alnus crispa, Empetrum nigrum, Calamagrostis canadensis, Rumex arcticus, Salix pulchra, Leymus mollis, Rubus chamaemorus* and *Arctagrostis latifolia*, 68.856°N 136.918°W 2 m *B. A. Bennett, M. J. Oldham, C. A. Kennedy, P. Seccombe-Hett & D. C. Gordon 06-323*, 30 July 2006 (CAN) (identified by G. W. Argus).

The following key will help identify the subspecies, but there are extensive areas of overlap between them and many intermediates.

1a. Stipules on later leaves foliaceous and prominent, often persistent for more than one year, mostly linear to lanceolate-inequilateral, 2–17 mm; branchlets generally very densely villous but becoming glabrous; branches generally red-brown but sometimes gray- to yellow-brown; proximal leaves entire; floral bracts 1.2–2.5 mm; ovaries generally obclavate, sometimes pyriform; staminate flowering branchlets 1–14 mm; northwestern Canada and Alaska. 2

2a. Shrubs 0.25–1 m; branchlets generally villous; petioles shorter, 1–9 mm; largest medial leaf blade apex acute, moderately densely to sparsely hairy adaxially; staminate catkins 14–26 mm; filaments glabrous or hairy, distinct to partially connate; pistillate catkins stout to subglobose, flowering branchlet 2–19 mm; stipe 0.4–1.8 mm; arctic Alaska and Northwest Territories and western Nunavut 50a.
. . . . *Salix glauca* subsp. *stipulifera*

2b. Shrubs 0.25–6 m; branchlets soon becoming pilose or glabrous; petioles longer, 4–27 mm; largest medial leaf blade apex acute to sometimes acuminate, often sparsely hairy adaxially; staminate catkins 19–45 mm; filaments glabrous, distinct; pistillate catkins slender to stout, flowering branchlet 3–37 mm; stipe 0.5–2.8 mm; central Alaska and Yukon east to Great Slave Lake, Northwest Territories 50b.
. . . . *Salix glauca* subsp. *acutifolia*

†*Salix sphenophylla* Skvort, Wedge-leaf Willow – (Addition – N)

This Amphi-Beringian species was included in Cody (1996) as a species to be expected in Yukon as its known distribution included areas in adjacent coastal Alaska and also from Cape Dalhousie just east of the Mackenzie River delta.

Specimen examined: Ivvavik National Park, unnamed creek north of Muskeg Creek near Firth River, Uncommon in graminoid wetland ribbon fen toe of slope 3% southwest-facing. Very poorly drained terric fibric organic cryosol, 95% moss cover dominated by *Carex lugens, C.rotundata, Betula glandulosa, Andromeda polifolia* with *Salix candida* in 10% open water. 68.87703°N 140.3775°W, 486 m, *B. A. Bennett, S. Wolfe & M. Kirk 08-312*, 23 July 2008 (CAN) (identified by G. W. Argus).

POLYGONACEAE Buckwheat Family

†*Polygonum douglasii* Greene ssp. *douglasii*, Douglas' Knotweed – (Addition – N) Figure 3.

Polygonum douglasii is the only member of the *Polygonum* section *Duravia* in the Territory. This native annual plant was previously known from the vicinity of the Stikine and Peace rivers in northern British Columbia so the Yukon collection is an extension of nearly 400 km. The occurrence of this species is in an extremely remote location and so is likely a natural occurrence.

Crow River Hot Springs, rare, the only place seen, <100 plants, 20° south-facing slope growing with *Draba nemorosa, Arctostaphylos uva-ursi, Anaphalis*

margaritacea, Potentilla arguta, Collomia linearis, Phleum alpinum, Aster ciliolatus, Amelanchier alnifolia, Solidago canadensis, and *Hieracium umbellatum*, sandy soil, 60.199°N 125.789°W, 975 m, *B. A. Bennett, P. Seccombe-Hett & J. Legare 04-0803*, 16 July, 2004 (ALA, DAO).

It can be separated from section *Polygonum* as follows (from Costea *et al.* 2005):

1a. Stems distinctly and + regularly 8-16 ribbed; leaf blade venation pinnate, secondary veins conspicuous; anthers whitish yellow. .... *Polygonum* sect. *Polygonum*

1b. Stems 4-gonous, ribs obscure or absent; leaf blade venation parallel, secondary veins not conspicuous; anthers pink to purple. .... *Polygonum* sect. .... *Duravia* including *P. douglasii*

†*Rumex beringensis* Yurtsev & Petrovsky, Bering Sea Dock – (Addition – N). Figure 4.

The nearest collections known are also from the White River drainage in the Wrangell Mountains, Guerin Glacier terminus, Alaska, a distance of approximately 65 km (Murray 1971).

Specimen examined: Asi Keyi SMA, Boundary Lake, abundantly growing in pumice near shore of lake with *Carex rostrata*, 61°39.181'N 140°50.668'W, *P. Caswell 04-0955*, 22 July 2004 (ALA, CAN, DAO, WTU). This species is relatively widespread in wet areas including stream sides and lake shore in the vicinity of Boundary Lake.

Rumex beringensis is similar to *R. acetosella* in having dioecious flowers and linear leaves, but *R. beringensis* lacks the basal (hastate) lobes on the leaves and tepals have a free wing 0.3-0.5 mm wide, whereas in *R. acetosella* they are absent or barely visible. (adapted from Mosyakin 2005).

Rumex pseudonatronatus (Borbás) Murbeck (*R. domesticus* Hartman var. *pseudonatronatus* Borbás; *R. fennicus* (Murbeck) Murbeck), Finnish or Field Dock – (Addition – I)

This species was introduced to North America from eastern Europe and occurs mainly in the northern prairie region. Boivin (1968) reports a collection from "Dawson in Yukon," however the source of this report is unknown. *Rumex pseudonatronatus* is commonly mistaken for *R. crispus* or occasionally the less common *R. longifolius*. The specimen cited below is therefore a new introduced species to Yukon.

Specimens examined: Labiche Airstrip, roadside herbaceous meadow beside airstrip, 60°07'42"N 124°02'21"W, 1200', *B. A. Bennett & P. Seccombe-Hett 04-0566B*, 12 July 2004 (BABY, photo DAO).

Rumex pseudonatronatus is commonly mistaken for *R. crispus* or occasionally the less common *R. longifolius*; it can be separated from these species as follows (adapted from Mosyakin, 2005):

1a. Mature valves rotund- or reniform-cordate, as broad or broader than long; leaves tapering to base 2

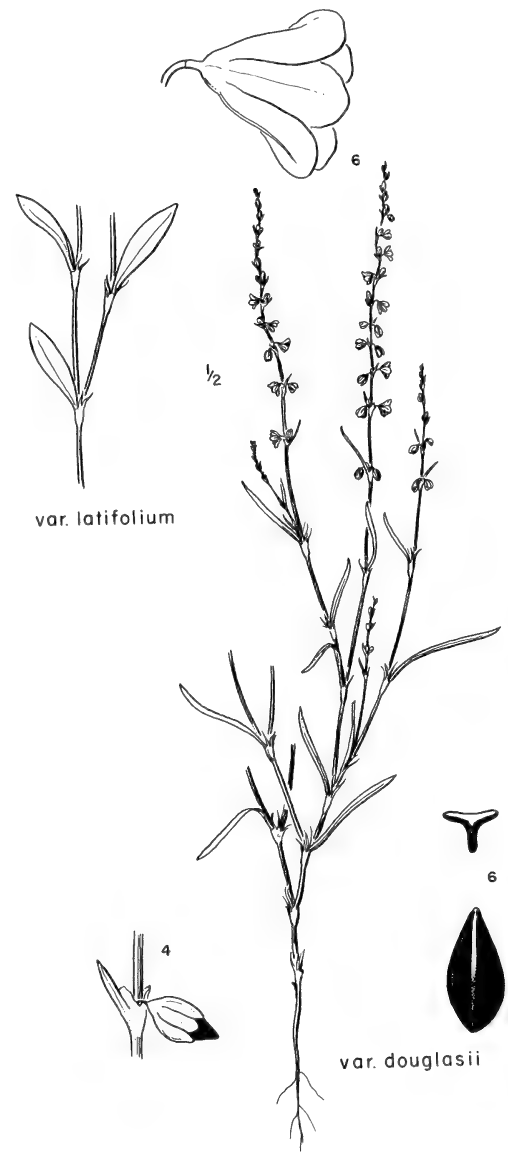


FIGURE 3. *Polygonum douglasii* ssp. *douglasii* illustration by J. R. Janish courtesy of the University of the Washington Press.

1b. Mature valves broadly ovate, longer than broad; lower leaves truncate, subcordate, or cordate at base. .... *R. crispus*

2a. Leaves narrowly lanceolate, their margins very strongly wavy-curled (appearing shallowly pinnatifid when pressed); achenes usually reddish brown, 2-2.5 × 1-1.5 mm; stems purplish or reddish brown at maturity. .... *R. pseudonatronatus.*

2b. Leaves oblong-lanceolate to oblong on narrowly ovate, flat or merely slightly undulate; dark brown or brown, (2.5) 3-3.5 (4) × 1.5-2 mm. . . . . *R. longifolius*

CARYOPHYLLACEAE Pink Family

Silene soczaviana (Schischk.) Bocquet var. *macrosperma* (A. E. Porsild) V. V. Petrovsky, D. F. Murray & Elven, (*Melandrium macrospermum* A. E. Porsild; *Silene macrosperma* (Porsild) Hultén; *S. soczavana* (Schischkin) Bocquet, *S. uralensis* (Rupr.) Bocquet ssp. *porsildii* Bocquet), Large-seeded Nodding Campion – (Addition – N)

Morton (2005) reports this species as occurring in Yukon, though no other reports of specimens bearing this name are known for the territory.

Specimens examined: Vuntut National Park, Dog Creek crest of Mountain west of camp, rare collected only once, on open mountain summit west of camp, 68°27'42"N 138°42'05"W, 2481', *B. A. Bennett, R. Markel, R. Lewis, B. Njootli (Farkus) & L. Nukon 00-0952*, August 3, 2000 (DAO) (confirmed by D. F. Murray 2006 and J. Morton 2008); Ogilvie Mountains, Blackstone River drainage, site 16, uncommon in patches amongst large boulder talus, with *Salix dodgeana, Carex glacialis, Dryas alaskensis, Cardamine purpurea* and *Lesquerella calderi*. SW-facing 45° slope limestone bedrock, 65.66064°N 137.09242°W, 4230', *B. A. Bennett, D. Cooley & H. Guest 05-0131*, June 29, 2005 (ALA, DAO); Martha Black Peak, along trail to peak, 60.68°N 137.55°W, *P. P. Caswell 518*, August 2, 2000 (ALA); Kaskawulsh nunatak, junction of north and central arms Kaskawulsh Glacier, moist, shaded soil, 60.7333°N 139.1667°W, 1829 m, *D. F. Murray & B. M. Murray 62 & 82*, July 1, 1965 (ALA); Slims River, NW of, high alpine slopes, screes, 60.9167°N 138.7167°W, 1921 m, *D. F. Murray & B. M. Murray 867*, July 7, 1967 (ALA); Slims River, NW of, high elevation limestone scree, 60.9167°N 138.7167°W, 1921, *D. F. Murray & B. M. Murray 1553*, June 30, 1968 (ALA); Steele Glacier and vicinity, W of Burwash Landing, talus slopes, 61.2667°N 140.1333°W, 2134 m, *D. F. Murray & B.M. Murray 1345*, August 7, 1967 (ALA); Windy Pass and vicinity, shale scree, N-facing, 65.0667°N 138.25°W, 1679 m, *C. L. Parker 1021*, June 23, 1984 (ALA) (confirmed by D. F. Murray and R. Elven).

Silene soczavana var. *macrosperma* can be separated from other subspecies in the genus as follows (adapted from Morton 2005):

1a. Inflorescences usually simple, pedicels slender with single nodding (deflexed) flower (fruiting pedicels erect); seeds 1.5-2 (2.5) mm diameter (including broad wing). . . . . *Silene uralensis* ssp. *uralensis*

1b. At least some of the inflorescences branched with 2 to several flowers, pedicels erect to angled but not deflexed except at tip in flower; 2-2.5 mm diameter. 2

2a. Stems usually glabrous to sparsely, rarely pubescent, (15) 20-40 cm, slender; inflorescences branched with with (1) 2-10 flowers; corolla only slightly exceeding calyx. . . . . *Silene uralensis* ssp. *ogilviensis*

2b. Stems densely pubescent with purple-septate hairs, 10-35 cm, stout; at least some inflorescences forked with 1-3(-4) flowers; corolla usually ca. 1 ½ times calyx. . . . . *Silene soczavana* var. *macrosperma*

NYMPHAEACEAE Water-Lily Family

†*Nymphaea tetragona* Georgi, Pygmy Water-lily – (Addition – N)

This species was reported as *Nymphaea tetragona* ssp. *leibergii* (Morong) Pors. *in* Hultén (1950) from a collection made by J. P. Anderson (9160) on the Alaska Highway near the Canadian Border (ALA). It was mapped at this locality in Hultén (1968). Cody (1994) felt the dot depicted in Hultén (1968) was "a misplacement for the *Anderson 9160* collection". He felt the dot should have come from the Haines Highway and not the Alaska Highway reasoning that, "A collection by C. H. D. Clarke at Mile 85 Haines Road (CAN) which was initially thought to have been made in the Yukon Territory was later proved to be from northern British Columbia a few miles south of the Yukon border." Cody (1996) suggests the species should be looked for in the southern Yukon Territory, and it is known from Alaska and also the southern parts of Northwest Territories where *Nymphaea leibergii* also occurs (Catling 2005).

During a vegetation survey in the vicinity of Beaver Creek, *N. tetragona* was found to be fairly abundant in shallows growing with Nuphar, several dozens of flowers seen, this is the only lake where found, wetland #13, along west side of one of the Enger Lakes, on west side of Alaska Highway, 62.240°N 140.693°W, 776 m, *L. Schroeder & R. Rosie LS-WP72-JY31*, 31 July, 2006. This collection may be from the same locality as Anderson's earlier collection.

BRASSICACEAE Mustard Family

Camelina microcarpa Andrz. *ex* DC, Little Pod Falseflax – (Addition – I)

This species is new to the Yukon flora based on a collection previously identified as *C. sativa* (see below). A second older collection was found housed in the UBC herbarium as an unidentified species of *Camelina* and identified by BAB as this species as well. An introduced species from Eurasia, *C. microcarpa* is known from the Mackenzie District of the Northwest Territories (Cody 1956, 1961) but has not been reported from Alaska.

Specimens examined: Whitehorse Shipyards, disturbed site, 60°43'34"N 135°03'12"W, *B. Bennett 01-150*, 28 Aug. 2001 (BABY, photo DAO). Whitehorse, open ground, back yards etc., *V. C. Brink sn*, 30 June 1943 (UBC 51786).

These two species of *Camelina* can be separated as follows (key adapted from *The Flora of North America* and Douglas et al. 1998b):

1a. Fruits 3.5-7 mm, valves obscurely veined; seeds 0.8-1.0 mm; stems hairy below with some simple trichomes to 1-3.5 mm, these often mixed with smaller branched ones. ...... *Camelina microcarpa*

1b. Fruits 6-9 mm, valves prominently veined; seeds 1.5-2 mm; stems basally glabrous or almost exclusively with minute branched trichomes, simple trichomes rarely present. ... *Camelina sativa*

Camelina sativa (L.) Crantz ssp. *sativa*, Gold-of-Pleasure – (Deletion – I)

This was erroneously reported as new to the Territory (Cody *et al.* 2004) based on a misidentification of *Camelina microcarpa* (see above). Although *C. sativa* has not been found out of cultivation in Yukon, it can survive a Yukon winter and is expected to become established. Plants were able to produce viable seed and self-seed in agricultural trials at the Takhini Forestry Farm Demonstration Site, where it was cultivated for research. The specific site was near Whitehorse: Takhini Hot Springs Road, Gunnar Nilsson and Mickey Lammers Research Forest 60.856°N 135.208°W 666 m *B. A. Bennett & M. Ball 07-264* 17 August, 2007 (MO) (confirmed by Ihsan A. Al-Shehbaz). Since *Camelina sativa* has been reported from the Mackenzie District of the Northwest Territories (Cody, 1956, 1961) and Alaska (Carlson & Shepherd, 2007) it should be expected to be found in Yukon, but interestingly it has not yet been reported as definitely naturalized in any northern North American jurisdiction.

Erysimum cheiri (L.) Crantz, Common Wallflower – (Deletion – I)

Cody *et al.* (2002) reported a collection of this species from Whitehorse, Yukon (Cody & Cody 37439). It had grown from a "wildflower seed mix" planted by the City of Whitehorse and is not a persistent species.

SAXIFRAGACEAE Saxifrage Family

Saxifraga hyperborea R. Br., (*S. rivularis* L. var. *flexuosa* (Sternberg) Engler & Irmscher; *S. rivularis* ssp. *hyperborea* (R. Br.) D. Dorn), Pygmy Saxifrage – (Addition – N)

The majority of plants referred to as *Saxifraga rivularis sensu lato* reported throughout northern and western North America, including all those reported by Cody (1996) that have been examined by BAB are referable to *Saxifraga hyperborea* R. Br. which occurs throughout Yukon to the Arctic coast.

Exemplary specimens examined: Mountain between Kusawa and JoJo Lakes, 60°35'47"N 136°15'19"W, 6300', *B. A. Bennett, D. E. Russell & G. W. Kuzyk 97-645*, Sept.19, 1997, wet alpine rich tundra below cirque. (DAO, BABY); Printer's Pass, 61°11'40"N 138°19'30"W, 5274', *B. A. Bennett 01-122*, July 15, 2001, alpine meadow in moist area at base of cliff, rare only three plants seen. (BABY); Kluane National Park, Fisher Glacier near Alsek, W-facing slope above valley glacier leading into Fisher Glacier, 60°08'20"N 138°13'20"W, 3800', *B. A. Bennett 03-0999*, July 7, 2003, base of rock outcrops and in talus, poorly vegetated with *Saxifraga reflexa* and *Cardamine bellidifolia*. (YG); Kluane National Park, Fisher Glacier near Alsek, base camp; 60°08'31"N 138°13'13"W, 3620', *B. A. Bennett 03-1084*, July 6, 2003, occasional in seepy areas along creeks and rock bluffs. (DAO); Kotaneelee Ridge, south end; 60.20937°N 124.1129°W, 1437 m, *B. A. Bennett, R. Rosie & C. Guppy 04-0645*, July 13, 2004, Small depression forming little lake dominated by *Eriophorum*, moss, *Salix reticulata, Carex podocarpa* and *Betula glandulosa*. Limestone bedrock. (DAO); LaBiche Range, 60.44792600°N - 124.42288913°W, 1666m, B. A. Bennett & P. Seccombe-Hett 04-0659, July 14, 2004, SSE-facing vertical cliff faces of limestone bedrock, growing in moist rich herbaceous meadows with *Claytonia tuberosa, Saxifraga reflexa, Petasites frigidus, Oxyria digyna, Trisetum spicatum, Artemisia norvegica* ssp. *saxatilis, Polemonium acutifolium, Arctagrostis latifolia*, and *Ranunculus pygmaeus*. (DAO); Asi Keyi SMA, Brooke Creek, plateau north of, camp, 61°33'34.8"N 140°49'03.6'N, 1489m, *B. A. Bennett & P. Seccombe-Hett 04-0940*, July 22, 2004, Common, growing amongst cobbles along edges of an ephemeral creek with *Artemisia tilesii* and *Festuca richardsonii*. (YG); Asi Keyi SMA, headwaters of Wolverine Creek by glacier, 61°25.876'N, 140°11.001'W, 6862', *P. Caswell, J. Meikle & F. Mueller 04-1083*, July 25, 2004, Uncommon in rock and boulder field at edge of glacier, growing in organic soil. (DAO); Asi Keyi SMA, Kluane Range, mountain NW of Sergerent Creek, 61°42'32.5"N, 140°19'21.3"W, 2186m, B. A. Bennett & P. Seccombe-Hett 04-1137, July 26, 2004; Commonly growing in rock and boulder pavement in organic soil at mountain summit. Bedrock granite, 20% vegetation cover. East-facing 5° slope. (DAO); Bonnet Plume Drainage, Gillespie Lake, 64.70740216°N 134.01495472°W, 5270', B. A. Bennett, P. Seccombe-Hett, J. Ryder, S. Thompson & D. Mahoney 05-1226, July 13, 2005, Occasional in wet mossy areas along edges of mountain stream at the elevational extreme of vegetation. Mountain stream has almost no grade. (DAO, O) (Confirmed by R. Elven January 2007); Blow River Delta, 68.92228475°N 137.17964603°N, 30', *B. A. Bennett, T. McIntosh, J. Line, J. Staniforth and D. C. Gordon 05-0922*, July 26, 2005, Occasional on dry sand banks on northeast-facing slopes above stream draw. Growing with *Oxytropis nigrescens, Carex rupestris, Poa glauca, Trisetum spicatum* and *Selaginella sibirica*. At the mouth of an arctic ground squirrel burrow. (O) (confirmed by R. Elven January 2007); Richardson Mountains, tributary of Fish Creek, S of Vunta Creek; 67.87537°N 136.56293°W, 1000 m, *B. A. Bennett & M. J. Oldham 06-567*, August 5, 2006,

Occasional in eroding shale bank at late snowmelt site. Wet growing with *Ranunculus nivalis, Saxifraga cernua, Taraxacum alaskanum* and *Cardamine microphylla*. (CAN, DAO); Blow River Delta, mainland sites S of E delta, rich bluffs, 68.87245°N 136.97964°W, 1 m, *B. A. Bennett, M. J. Oldham, C. A. Kennedy, P. Seccombe-Hett & D. C. Gordon 06-253*, July 29, 2006, Occasional in wet seepy area in muddy shaley soil, late snow melt patch. Poorly vegetated. Growing with *Carex podocarpa, Saxifraga radiata*, and *Ranunculus pygmaeus*. (CAN, DAO, O); Mount Sedgwick, 68.87295°N 139.14218°W, 905 m, *B. A. Bennett & S. Wolfe 08-414*, July 25, 2008, Occasional, growing in seepy areas below rock outcrops and boulders with *Potentilla hyparctica, Poa paucispicula, Ranunculus nivalis* and *Trisetum spicatum*. (ALA, CAN); Mount Conybeare, 69.46454°N 140.07408°W, 459 m, B. A. Bennett & S. Wolfe 08-301, July 26, 2008, 65% N-facing slope, late snowmelt patch, lots of leaf litter that was deposited on snow. Growing with *Ranunculus pygmaeus, Geum glaciale/Cassiope tetragona/Saxifraga bronchialis*, argillite bedrock. (CAN, UBC)

Saxifrage rivularis ssp. *arctolitoralis* has been recently discovered in Yukon (see below). In Yukon, these two taxon may be separated by habitat and growth form; *S. rivularis* ssp. *arctolitoralis* growing in brackish areas forming cushions, where as *S. hyperborea* growing on the coast is only found in fresh seepage areas, is more delicate and very loosely growing. The most reliable differentiation is based on rhizomes which are absent in *S. hyperborea* but present in *S. rivularis* ssp. *arctolitoralis* (Jørgensen, et al. 2006).

†*Saxifraga rivularis* L. *ssp. arctolitoralis* (Jurtz. & V. V. Petrovsky) Jorgensen & Elven (*S. arctolitoralis* Jurtz. & V. V. Petrovsky), Arctic Coast Saxifrage – (Addition – N). Figure 5.

Saxifraga rivularis is a circumpolar species with two subspecies found on Arctic seashores on silt and clay, sloping soil banks. The subspecies *rivularis* is a plant of snowbeds, damp tundra, bird-manured cliffs, springs, seepage slopes, brook margins and silty or gravelly seashores. It is Amphi-Atlantic in distribution extending from the Russian Arctic coast from West Taymyr to Baffin Island south to the Gaspé Peninsula, Quebec and White Mountains, New Hampshire (Jørgensen et al. 2006).

The subspecies *arctolitoralis* is Amphi-Beringian found from the northern coast of Chukotka and Wrangel Island, east to the Arctic Pacific from the Seward Peninsula to Barrow (Jørgensen et al. 2006). The discovery of this taxon in Yukon extends its distribution farther eastward to Shingle Point. No plants were seen east of Running River.

Specimens examined: Shingle Point area, mainland opposite, common on moist brackish areas occasionally flooded by high tides, growing in seepage areas with *Puccinellia phryganodes* and *Ranunculus pygmaeus*, 68.985°N 137.420°W, 2', *B. A. Bennett, T. McIntosh, J. Line, J. Staniforth & D. C. Gordon 05-0782*, 25 July 2005 (O); King Point, uncommon in depressions in slightly brackish flats on the southeast side of lagoon in sand with *Matricaria ambigua, Ranunculus pygmaeus* and *Minuartia rubella*, 69.094°N 137.968°W, 2', *B. A. Bennett, T. McIntosh, J. Line, J. Staniforth and D. C. Gordon 05-0866*, 27 July 2005 (ALA, O); Ivvavik National Park, Ptarmigan Bay, common along shore of bay in muddy banks, 69.464°N 139.066°W, 5', *B. A. Bennett, C. L. Parker, T. McIntosh, P. Seccombe-Hett and M. Joe 05-1050*, 9 August 2005 (O); Kay Point, common at base of silty south-west facing bank along broad slow stream flowing into lake with *Antennaria friesiana* and *Ranunculus pygmaeus*, 69.273°N 138.378°N, 10', *B. A. Bennett & T. McIntosh 05-1131*, 2 August 2005 (CAN, O) (all collections confirmed by R. Elven 2007).

FIGURE 4. *Rumex beringensis* photo credit B. Bennett.

Saxifraga rivularis ssp. *arctolitoralis* may be separated from ssp. *rivularis* as follows (Jørgensen et al. 2006):

1a. Hypanthium sparsely covered by short glandular hairs (0.15-0.25 mm) with non-coloured or weakly coloured

partition walls. The whole plant green or with some purple pigmentation in the inflorescence. Flowering stem long, 27-70 mm, glabrous or sparsely hairy. .... ssp. *rivularis*

1b. Hypanthium densely covered by long glandular hairs (0.3-0.6 mm) with purple partition walls. The whole plant or at least the inflorescence purple-pigmented. Flowering stem short, 17-30 mm, sparsely to densely hairy. .... ssp. *arctolitoralis*

ROSACEAE Rose Family

Potentilla crebridens Juz. ssp. *hemicryophila* Juz., Beringian Cinquefoil – (Addition – N, Canada also)

Cody (1996) misapplied the long accepted name of *Potentilla nivea* L. to plants belonging to *P. arenosa* (Turcz.) Juz. (*P. hookeriana* Lehm.). Plants with floccose petioles that "had been understood as *P. nivea* were now given the very unfamiliar name *P. prostrata*" (Elven and Murray 2008b). "Yurtsev (1984) decided that the Beringian plants with floccose petioles actually consisted of two species: *P. nivea* s. str. and *P. crebridens* Juz., and within that latter species he recognized a northern subsp. *hemicryophila* Jurtz. This subspecies was reported by him as widespread in Alaska, together with *P. nivea*." (Elven and Murray 2008b). The collections cited below represent a previously unreported species for both Yukon and Canada. Plants referred to as *P. prostrata* should be reviewed.

Specimens examined: Bonnet Plume Drainage, Quartet Lake, occasional on xeric platey argillite 30° west-facing slopes and rock outcrops, poorly vegetated with *Dryas alaskensis, Minuartia arctica, Saxifraga reflexa, Oxytropis viscida, Phlox alaskensis, Woodsia glabella, Artemisia alaskana, Bupleurum americanum, Calamagrostis purpurascens* and *Dryopteris fragrans*, 63.119°N 134.421°W, *B. A. Bennett, P. Seccombe-Hett, S. Thompson & D. Mahoney 05-0395*, 8 July 2005 (ALA, DAO) (confirmed by D. F. Murray); Asi Keyi SMA, Wolverine Plateau "Red Rock", Rarely found growing in 2" loose scree at bottom of slope south-facing slope above ephemeral river, 61°32'13.8"N 140°11'57.6"W, 1593m, *B. A. Bennett & P. Seccombe-Hett 04-1060*, July 25, 2004 (ALA, CAN, DAO) (identified by C. L. Parker, March 2006, confirmed by D. F. Murray) Ivvavik National Park, dry calcareous heath, 69.41°N 139.63°W, *R. Elven 2269/99*, 04 August, 1999 (ALA); Ivvavik National Park, Sheep Creek drainage, Parks Canada base camp, Common on open soil with *Zygadenus elegans, Salix glauca, Potentilla fruticosa, P. subgorodkovii* and *Dryas integrifolia*, south-facing slope on upper bench. 69.16109°N 140.15515°W, 241 m, *B. A. Bennett, 08-665*, 14 July, 2008 (CAN, ALA); Ivvavik National Park, Sheep Creek drainage, Uncommon on argillite bedrock outcrop dominated by *Dryas alaskensis, Cassiope tetragona, Vaccinium vitis-idaea, Saxifraga bronchialis, Saxifraga tricuspidata, Lupinus arcticus, Anemone multiceps* and *Salix glauca*. NE-facing 30° slope. Growing with *P. villosula*, 69.15971°N 140.20885°W, 472 m, *B. A. Bennett, S. Wolfe & S. McLeod, 08-467*, 15 July, 2008, (ALA); Ivvavik National Park, Malcolm River, common on *Dryas/Hedysarum* stable alluvial river terrace, 69.2897°N 140.47318°W, 446 m, *B. A. Bennett & S. Wolfe, 08-362*, 22 July, 2008, (ALA); Ivvavik National Park, Mount Coneybeare, locally common on *Dryas* heath tundra in shaley saddle <10% *Artemisia glomerata/Dianthus repens/Smelowskia media/Dryas alaskensis/Salix phlebophylla/Potentilla nivea*, 69.47323°N 140.06461°W, 464 m, *B. A. Bennett & S. Wolfe, 08-454*, 26 July, 2008 (ALA); Ivvavik National Park, Babbage River drainage, alpine slope, 68.78558°N 138.8115°W, 341m, *B. A. Bennett, I. Olthof, R. Fraser & G. Brooks, 08-293*, 27 July, 2008 (ALA).

FIGURE 5. *Saxifraga rivularis* ssp. *arctolitoralis* photo credit B. Bennett.

Potentilla crebridens can be separated from other members of the *Niveae* section in Yukon as follows (from Elven and Murray, 2008b):

1a. Petioles with short tomentum of floccose hairs; central leaflet not distinctly stipitate

2a. Epicalyx bractlets elliptic or lanceolate, nearly as broad as sepals; styles with several distinct basal papillae; leaflets not overlapping, central leaflet with 3–5 well separated teeth per side, upper surface not densely hairy (green), base cuneata .... *P. nivea*

2b. Epicalyx bractlets linear, much narrower than sepals; styles with few basal papillae; leaflets overlapping, central leaflet with 4–8 approximate teeth per side,

upper surface mostly densely hairy (gray), base broadly cuneate
. . . . *P. crebridens* subsp. *hemicryophila*

1b. Petioles without floccose hairs, with upper layer of long straight verrucose (50× magnification) hairs; central leaflet distinctly stipitate.
. . . . *P. arenosa* (*P. hookeriana*)

Prunus padus L., Maytree or European Bird Cherry – (Addition – I). Figure 6.

This is a widespread cultivated species throughout Yukon in populated areas. Individual trees are known to be in excess of 70 years old. Several seedlings have been found over the past several years and the plant has been seen naturalized and producing fruit. In addition to the locations cited below, many small plants several years old have also been seen in natural areas around Whitehorse including Bert Law Park and on the Yukon College campus.

Specimens examined: Found in *Picea glauca* forest at base of bluff at rest area 2-3 km south of Carmacks. *B. A. Bennett, R. Elven & H. Solstad 03-1303*, 25 August, 2003 (DAO); Kishwoot Island, Whitehorse, rare, only one shrub seen 4 m tall with *Salix scouleriana, Alnus incana, Ribes hudsonianum* and *Rubus acaulis*, 60.7317°N 135.065°W, *B. A. Bennett & R.S. Mulder 06-034*, 3 July, 2006 (DAO).

Prunus padus has white flowers and black fruits in elongate terminal racemes similar to the native *P. virginiana* from which it can be separated as follows:

1a. Calyx-tube and hypanthium pubescent within, petals 6-10 mm, stone sculptured. . . . . *P. padus*

1b. Calyx tube and hypanthium glabrous within, petals 2.5-4 mm, stone smooth. . . . . *P. virginiana*

FIGURE 6. *Prunus padus* photo credit B. Bennett.

Specimen examined: Cultivated but self-seeding in the yard and surrounding alley, Whitehorse, Steele Street, 60°43'11"N 135°03'35"W, 2063', *B. A. Bennett 03-0018*, 27 May 2003. (BABY).

FABACEAE Pea Family

Medicago lupulina L., Black Medick – (Addition – I)

Cody (1996) suggested that this introduced species should be expected to be found about townsites.

Specimen examined: North Klondike Highway, km 678, Dempster Corner Services, where it was rare on disturbed ground beside car washing station, 63.991°N 138.750°W, 433 m, *B. A. Bennett & R. S. Mulder 07-229*, 30 July 2007 (DAO). *Medicago lupulina* should be added to the Yukon flora.

ACERACEAE Maple Family

Acer negundo L., Manitoba or Ash-leaf Maple – (Addition – I)

This species is native to North America but introduced to Yukon. It is a common cultivated plant in communities, where it has occasionally become naturalized. It has previously been known from Northwest Territories (Cody, 1961) and from northern British Columbia as least as far north as Chetwynd (Klinkenberg 2009); however, it has not been reported from Alaska (Carlson and Shepherd 2007; University of Alaska 2009). It has not yet been found in undisturbed woodlands.

BALSAMINACEAE Touch-me-not Family

Impatiens noli-tangere L., Western Touch-me-not – (Addition – N). Figure 7.

Cody et al. (2000) cited a specimen collected from a roadside ditch west of bridge, Labiche River (*B. A. Bennett 98-285*, 15 June 1998) as *Impatiens ?capensis*. This specimen has now been revised to *I. ? noli-tangere* by P. Zika (WTU). *Impatiens* produces two forms of flowers, cleistogamous (obilgate self-pollinating flowers) and outcrossing flowers. Cleistogamous flowers are produced first and allow these annual plants to reproduce. The larger outcrossing flowers are required to positively identify the plant to species. Several collections have been made that have cleistogamous flowers and mature fruit but none have been collected with outcrossing flowers. As the identity of this species still remains uncertain, additional collections are required.

Specimens examined (likely referable to *I. noli-tangere*): Labiche, Lower Valley, in rotting vegetation in lee of downed log with *Circaea alpina* and *Viola selkirkii, Matteuccia struthiopteris* in surrounding area, 60.121°N 124.046°W, 368m, *B. A. Bennett & L. Schroeder 04-0702*, 14 July 2004 (ALA, DAO,

WTU); Labiche River boggy *Potentilla palustris* edge of beaver pond, 60.65°N 124.02°W, *B. A. Bennett 95268.1*, June 17, 1995 (DAO); Labiche River west of bridge, roadside ditch. 60°04'45"N 124°02'09"W, 1200', *B. A. Bennett, R. Rosie & J. Staniforth 98-285*, 15 June 1998 (DAO) (identified by P. Zika WTU); east of Labiche River, locally abundant in silty soil in disturbed site along pipeline right-of way with *Osmorhiza depauperata, Rubus idaeus, Rosa acicularis, Mentha arvensis, Taraxacum officinale, Aralia nudicaulis* and *Bromus inermis*. Also common in surrounding open riparian *Picea glauca / Betula papyrifera* forest growing in shaded areas with *Circaea alpina*, 60.145°N 124.042°W, 363 m, *B. A. Bennett, L. Mennell, V. Chisholm & M. Keeler 04-0533*, 12 July 2004 (ALA, DAO, WTU) (identified by P. Zika WTU).

These two species can be separated as follows (as suggested by P. Zika, see also Zika 2009):

1a. Gradual concave taper to spur; floral tube spots often dorsal, sparse. . . . . *I. noli-tangere*
1b. Abrupt and convex taper to spur; floral tube spots mostly ventral, often dense near throat. . . . *I. capensis*

Impatiens capensis Meerb., Spotted Touch-Me-Not – (Deletion – N)

The specimen cited by Cody et al. (2000) has been revised (see above).

ELATINACEAE Waterwort Family

Elatine triandra Schk., Eurasian Waterwort – (Deletion – N)

This species was reported based on a single collection from the Lower Blow River Delta (Cody 1994). The specimen has been revised to *Callitriche hermaphroditica* L. (M. Garneau QFA 2004).

ELAEAGNACEAE Oleaster Family

Hippophae rhamnoides L., Sea-Buckthorn – (Addition – I)

This species is a garden ornamental not commonly found in the territory. It has however been found to be capable of producing viable seed and colonizing disturbed areas. It has not yet been found in undisturbed natural areas.

Specimen examined: Whitehorse, Cowley Creek Subdivision, garden escape, selfing possibly by rhizomes, 60°35.45'N 134°53.72'W, 2350', *B. A. Bennett & R. S. Mulder 07-344*, 18 August 2007.

VIOLACEAE Violet Family

Viola tricolor L., Johnny-jump-up – (Addition – I)

This species is a garden ornamental commonly found in Whitehorse that local people report has been found naturalized and spreading for many years. It has been found to be capable of producing viable seed and colonizing disturbed areas. It has not yet been found in undisturbed natural areas. This new introduced species is widespread in Canada and has been reported from every jurisdiction except Labrador and Nunavut (Kartesz, 1999). It also occurs in Alaska (ALA).

FIGURE 7. *Impatiens noli-tangere* illustration by J. R. Janish courtesy of the University of the Washington Press.

Specimens examined: Whitehorse, Cowley Creek Subdivision, garden escape, 60.59031°N 134.89626°W, 723 m, *B. A. Bennett & R. S. Mulder 08-663*, 1 August, 2008. Whitehorse, Yukon Government Building, garden escape, 60,71658°N 135.04794°W, 634 m, *B. A. Bennett & R. S. Mulder 09-001*, 25 May, 2009.

Viola tricolor has larger petals (at least 3 mm longer than the sepals) than *Viola arvensis* Murray, the other widespread introduced (in North America) violet with pinnate and leafy stipules. The former can be separated from other members of the genus in Yukon by the following characters (adapted from Douglas *et al.*, 2000):

1a. Plants annual, with leafy stems bearing large, deeply lobed leaf-like stipules . . . . *V. tricolor*

1b. Plants perennials, lacking leafy stems or the stems not bearing large and deeply lobed leaf-like stipules . . . . *Viola* spp.

LAMIACEAE Mint Family

Lamium amplexicaule L., Giraffehead – (Addition – I). Figure 8.

This introduced species is found throughout North America except Alaska and Nunavut.

Specimen examined: Collected at the Whitehorse International Airport, in cobbles outside entrance, weedy, growing amongst wood chips in flower bed with *Dasiphora fruticosa*, *Stellaria media* and *Crepis tectorum*. Only place seen, 15 plants counted. Introduced. 60.714°N 135.076°W, 705 m, *B. A. Bennett & S. Green 07-301*, 21 August 2007 (DAO). Found again at the same site in 2008. It should be added to the Yukon flora.

Lamium can be separated from other members of Lamiaceae in Yukon with the combination of characters as follows (adapted from Douglas et al. 1999):

1a. Plants annual, corolla more or less 2-lipped, stamens 4, inflorescences axillary or appearing terminal, calyx teeth 5, north hooked at the tips. 2
2a. Stems glabrous to inconspicuously hairy. . . . *Lamium*
2b. Stems bristly hairy with red or yellow gland-tipped hairs. . . . . *Galeopsis*

SCROPHULARIACEAE Figwort Family

Linaria dalmatica (L.) P. Mill. (*L. genistifolia* (L.) P. Mill. ssp. *dalmatica* (L.) Maire & Petitmengin), Dalmatian Toadflax (Addition – I). Figure 9.

Two plants found, one growing nearly four feet tall with old stalks of previous season still attached was found on the Alaska Highway one kilometer west of Spencer Creek, on a steep gravel embankment, 60.141°N 130.231°W, *B. A. Bennett, R. Rosie & L. Schroeder 04-1271*, 9 July 2004 (ALA, DAO). The plants were removed and a search of the site in 2007 found no sign of this potential invasive plant remaining.

Linaria dalmatica can be separated from the *Linaria vulgaris* as follows (adapted from Douglas et al. 2000):

1a. Leaves linear, 1-5 mm wide, not clasping at the base. . . . . *L. vulgaris*
1b. Leaves egg or lance-egg shaped, 10-20 mm wide, clasping at the base. . . . . *L. dalmatica*

RUBIACEAE Madder Family

Galium palustre L., Marsh Bedstraw – (Deletion – N)

This species was reported based on a single collection from near Sidney Creek on the South Canol Road (Porsild, 1951). The specimen (Number.10855) has been revised to *Galium trifidum* L. by B. A. Bennett with the following comments "stems scabrous, pedicels more scabrous than in *Galium palustre*; anthers not red." (CAN).

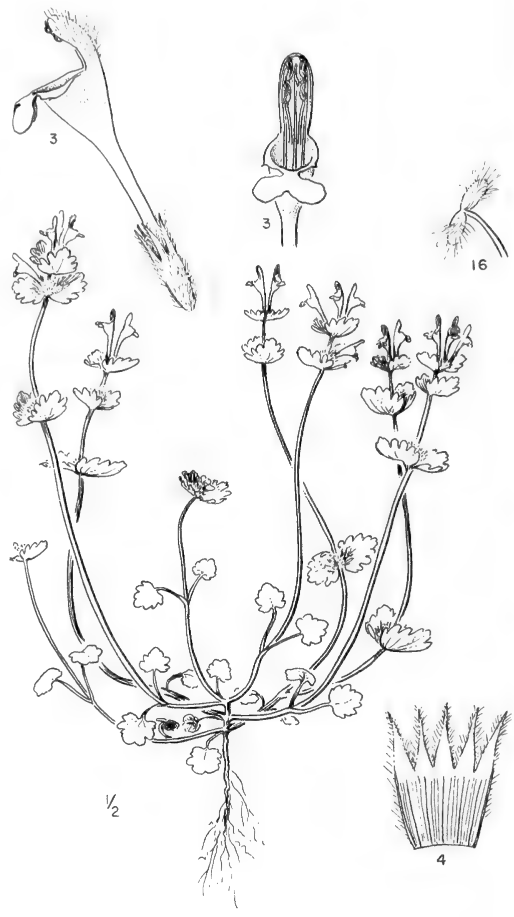


FIGURE 8. *Lamium amplexicaule* illustration by J. R. Janish courtesy of the University of the Washington Press.

VALERIANACEAE Valerian Family

Valeriana officinalis L., Garden Valerian – (Addition – I)

This species is commonly sold in the horticultural trade.

Specimen examined: Whitehorse, Cowley Creek Subdivision, garden plant self seeding and spreading into undisturbed native habitat, 60°35.45'N 134°53.72'W, 2350', *B. A. Bennett & R. S. Mulder 07-285*, 18 August 2007 (DAO).

Valeriana officinale may be separated from the native members of this genus by having lower leaves pinnately divided or compound with 8-12 leaflets, the terminal ones not much larger than the others.

ASTERACEAE Aster Family

Artemisia arctica ssp. *comata* (Rydb.) Hultén, (*A. norvegica* var. *comata* (Rydb.) Welsh; *A. comata* Rydb.,

A. n. ssp. *saxatilis sensu* Cody 1996 *pro parte)*, Boreal Sagebrush – (Addition – N, two taxa previously treated as one)

Hultén (1968) recognized *Artemisia arctica* subsp. *comata* as "a well-marked arctic race and shows its distribution throughout northern Alaska and Yukon including the north slope and northern Richardson Mountains. All the collections cited below fall within Hultén's estimated distribution. Many botanists over the years have accepted the tetraploid (2n=36) *A. comata* as a separate entity from the diploid (2n=18) *A. arctica*. Shultz (2006) discusses the complexity in the *A. norvegica* complex, and states that "if separated as distinct species then *A. arctica* is the name for the North American plants." As the taxon is distinctive in the field, even where subsp. *arctica* and subsp. *comata* grow together, it is recommended that this taxon be added to the Yukon flora. Being locally common where found, it does not however represent a species of conservation concern.

Specimens examined (ssp. *comata*): Malcolm River valley, braided cobble of river bed, 69°17'N 140°52'W, *W. J. Cody 27521*, 10 July 1980 (DAO, US) (det. B. A. Bennett); Arctic coastal plain near Firth River, sand dune area, 69°10'N 139°20'W, *L. R. Hettinger 285*, 17 July 1972 (ALTA) (det. W. J. Cody); Firth River, upland tundra not far from coast, 69°30'N 139°20'W, *E. H. McEwen 213*, 6 August, 1953 (CAN) (det. A. E. Porsild); Komakuk Beach, between runway and Beaufort Sea on a strip of narrow land. Site 16, in tundra beside sea dominated by sterile grass, probably Poa arctica, 69°37'N 140°07'W, 5 m, *S. G. Aiken 88-087*, 6 July 1988 (CAN) (det. A. W. Dugal); Arctic coast west of Mackenzie River Delta between King Pt. and Kay Pt., 69°12'N 138°30'W, *A. E. Porsild 7199*, 23-25 July 1934 (CAN) (det. D. F. Brunton); Clarence Lagoon, 69°37'N 140°46'W, 758', P. F. Cooper, 08 July 1979 (CAN) (det. J. M. Gillett); Upper Malcolm River, site XIII, 69°10'N 140°58'W, 1253', *P. F. Cooper*, 18 July 1979 (CAN) (det. B. A. Bennett); Ivvavik National Park, Clarence Lagoon, common on moist tundra on sandy windswept low beach head with open linear frost boils and low shrub/herbaceous meadows with dry and wet areas dominated by *Salix arctica, S. rotundifolia, Carex consimilis, C. maritima, Arctagrostis latifolia, Oxytropis maydelliana*, no ericaceous shrub, 69.6313°N 140.8380°W, 15', *B. A. Bennett, C. L. Parker, T. McIntosh, P. Seccombe-Hett and M. Joe 05-1213*, August 6, 2005 (ALA, DAO); Ivvavik National Park, Komakuk DEW Line station, common to abundant in sandy and gravelly areas throughout, one of the codominants along the shore and along the airstrip with *Senecio congestus, Carex aquatilis* and *Dupontia fisheri*, 69.5979°N 140.1782°W, 15', *B. A. Bennett, C. L. Parker, T. McIntosh, P. Seccombe-Hett and M. Joe 05-0637*, August 5, 2005 (DAO, UBC, UVIC); Ivvavik National Park, Komakuk River, common in gravel and sand along beach and throughout the mouth of the river one of the codominants growing with

FIGURE 9. *Linaria dalmatica* illustration by J. R. Janish courtesy of the University of the Washington Press.

Cochlearia officinalis and *Salix ovalifolia*, 69.6027°N 140.1319°W, 2', *B. A. Bennett, C. L. Parker, T. McIntosh, P. Seccombe-Hett and M. Joe 05-0754*, August 8, 2005 (DAO); Ivvavik National Park, Malcolm River, barrier beach at mouth of, common on beach sand on ocean side of lagoon, less than 5% vegetated open beach sand, 69°36.845'N 139°55.512'W, 5', *B. A. Bennett, C. L. Parker, T. McIntosh, P. Seccombe-Hett and M. Joe 05-0682*, August 5, 2005 (DAO, UBC); Ivvavik National Park, Nunaluk Spit, mouth of the Firth River, common on open gravel of spit on the protected side, and along airstrip with *Honckenya peploides, Artemisia borealis* ssp. *richardsoniana, Leymus mollis* and *Cochlearia officinalis*, 68.893°N 136.4295°W, 7', *B. A. Bennett, C. L. Parker, T. McIntosh, P. Seccombe-Hett and M. Joe 05-0746*, August 8, 2005 (DAO); Ivvavik National Park, Ptarmigan Bay, common in moist sand at edge of beach and tundra, forming large patches with *Saxifraga rivularis, Stellaria longipes, Draba lactea* and *Trisetum spicatum*, 69.4832°N 139.0817°W, 5', *B. A. Bennett, C. L. Parker, T. McIntosh, P. Seccombe-Hett and M. Joe 05-0711*, August 4, 2005 (ALA, DAO, V); King Point, common on moist areas of tundra dominated by *Salix richardsonii, S. pulchra, Petasites frigidus, Rubus chamaemorus*, 69.0942°N 137.9679°W, 2', *B. A. Bennett, T. McIntosh, J. Line, J. Staniforth and D.C. Gordon 05-0875*, July 27, 2005 (BABY).

Artemisia arctica subsp. *comata* can be separated from subsp. *arctica* as follows (adapted from Hultén 1968):

1a. Inflorescence open, glabrata or sparingly villous; lower peduncles elongate; leaves with narrow rachis. . . . . *A. arctica* subsp. *arctica* (*A. norvegica* ssp. *saxatilis*)
1b. Inflorescence lanate, spikelike; leaves with broad rachis, involucrum lanate, leaves noticeably fleshy. . . . . *A. arctica* subsp. *comata*

Crepis capillaris (L.) Wallr., Smooth Hawksbeard – (Addition – I)

This introduced European plant is not known to persist in the Territory; however collections of *C. tectorum* should be reviewed more closely. It has been reported from central Alaska and similar latitudes in northern Europe and seems therefore potentially capable of persisting. Hulten (1968) reports a single collection from central Alaska and another is known from the vicinity of Wrangell, Alaska (University of Alaska, 2009). In British Columbia it has been reported from the vicinity of Dease Lake and on the Alaska Highway between Muncho and Summit lakes (Klinkenberg 2009). Recent searches have not resulted in the discovery of any more plants at the single locality cited below.

Specimen examined: Beaver Creek, Mile 1202, ditch along highway, damp rocky soil, 62°23'N 140°53'W. *A. Roik 98-20*, 29 June 1998. (V #177921 – photocopy DAO) (determined by A. Ceska).

It can be separated from the common introduced roadside weed *Crepis tectorum* as follows (from Douglas et al. 1998a):

1a. Inner involucre bracts hairy within; mature achenes purplish-brown. . . . . *C. tectorum*
1b. Inner involucre bracts glabrous within; mature achenes tawny or pale brown. . . . . *C. capillaris*

†*Erigeron ochroleucus* Nutt., Buff Fleabane (Addition – N). Figure 10.

Nesom and Murray (2004) reported this species as new to Yukon based on the first collection listed below from Rampart House (Porcupine River) on the Yukon-Alaska border. The occurrence of this species in northern Alaska and Yukon represents a disjunct population over 2800 km from its' closest localities in southern Alberta and British Columbia. The other collections represent an additional range extension of 190 km to the north of the Porcupine River and the first to be found in Ivvavik National Park. Nesom and Murray (2004) recognize that though very restricted in Alaska, it is nevertheless common along that section of the Porcupine River. This is not the case in Yukon where the populations are far more restricted.

Specimens examined: Porcupine River, Rampart House on the Yukon-Alaska border, *C.C. Loan 568b*, 11 July 1951 (DAO); Firth River, west side opposite Muskeg Creek, gravelly limestone scree, 68°52'N 140°30'W, 700 m, *J. Pojar sn*, July 16, 2007 (DAO); Firth River, west side opposite Wolf Creek, scree slopes below shaly ridge, windswept, linear leaves, corollas whitish to lavender, 69°06'N 140°15'W, 1000 m, *J. Pojar & R. Pojar sn*, July 20, 2007 (DAO) (confirmed by D. F. Murray & G. L. Nesom); Ivvavik National Park, Sheep Creek drainage, Parks Canada base camp. Locally common in open silty soil is gravelly area on upper ridge by rock outcrops with Dall sheep enriched soils. Growing on *Dryas crenulata* tundra with *Carex rupestris, Pseudoroegneria spicata* and *Potentilla uniflora*. S-facing 10° slope. 69.16231°N 140.16167°W, 300 m, *B. A. Bennett, 08-089*, 16 July 2008 (ALA, CAN).

Erigeron ochroleucus can be separated from most other members of the genus by a combination of the following characters. Basal unclasping leaves linear to linear-oblancelolate, stems unbranched, involucres densely hirsute-villous, densely and minutely glandular. Flower ligules mostly white, less commonly bluish. With its narrowly oblanceolate leaves, solitary heads, and conspicuous ligules it resembles *E. hyperboreus, E. caespitosus* and *E. yukonensis*. It can be separated from these as follows (based on Nesom 2006):

1a. Plants with prominent taproots (taproots usually collected because rhizomes and fibrous roots are not well developed). 2
2a. leaves glabrous or glabrate abaxially, linear to linear oblanceolate, 1-4 (-5) mm wide. . . . . . *E. ochroleucus*

2b. leaves hairy on both surfaces, narrowly oblanceolate to spatulate, 2-15 mm wide. . . . . *E. caespitosus*
1b. Plants fibrous-rooted (taproots poorly developed and or not collected due to extensive rhizome or caudex system). 3
3a. Hairs of phyllaries with black or dark purple cross walls. . . . . *E. hyperboreus*
3b. Hairs of phyllaries with clear cross walls. . . . . *E. yukonenis*

†*Saussurea nuda* Ledeb. (*S. densa* (Rydb.) Hook., *S. nuda* ssp. *densa* (Hook.) G. W. Douglas, *S. nuda* var. *densa* (Hook.) Hultén, Dwarf Saw-wort – (Addition – N). Figure 11.

North American populations of *Saussurea nuda* have been segregated as var. *nuda* from coastal Alaska and var. *densa* including the dwarfed alpine plants from the northern Rockies of southern British Columbia and Alberta. Neither of these varieties have been retained in the most recent taxonomic treatment (Keil 2006). The collections reported here are located between the two populations but grow in mountainous alpine habitats. The collections reported below are all from northwest Yukon, however additional populations have been seen and collected by the first author at Chandler Lake, Gates of the Arctic National Park, Alaska, and photographed from the Richardson Mountains (Pojar 2008 personal communication). *Saussurea nuda* should also be looked for in southwest Yukon.

Specimens examined: Keele Range, Common on limestone talus scree upper and midslope 30° WSW-facing, dry to xeric, growing with *Carex misandra, Dryas octopetala, Silene soczavana, Saxifraga oppositifolia, Potentilla uniflora*, and *Smelowskia borealis*. 15% vegetated. 1162 m, *B. A. Bennett, J. Line, C. A. Kennedy & L. Mennell, 07-090*, 66.95543°N 140.81625°W, June 30, 2007, (BABY OBI) (Confirmed by D. J. Keil, Oct. 2008); Ivvavik National Park, Malcolm River drainage Alpine slope, 550-840 m, *B. A. Bennett & D. McLennan 08-366*, 69.27°N 140.6°W, July 23, 2008 (BABY); Ivvavik National Park, Upper Malcolm River, Locally common 35° N-facing slope, *Salix alaxensis* wet drainage slope, nivean, dominated by *Boykinia richardsonii, Dryas alaskensis* and *Geum glaciale* and throughout local talus slopes. 962 m, *B. A. Bennett, S. Wolfe & S. McLeod 08-440*, 69.20985°N 140.46008°W, July 21, 2008. (CAN, OBI) (Confirmed by D. J. Keil, October 2008). Though this species is likely more widespread than currently known, and its known populations are remote and in some cases protected within National Parks, it is still a rare element of the Yukon flora.

Saussurea ×*tschuktschorum* Lipschitz is apparently a hybrid between *S. angustifolia* and *S. nuda* (Keil 2006) and may be expected in Yukon. *Saussurea nuda* is most similar to *S. angustifolia* from which it can be separated as follows: (adapted from Keil 2006)

1a. Phyllaries subequal, linear to lanceolata, receptacles naked; heads 2-10+ in open or crowded corymbiform arrays. . . . . *S. nuda*

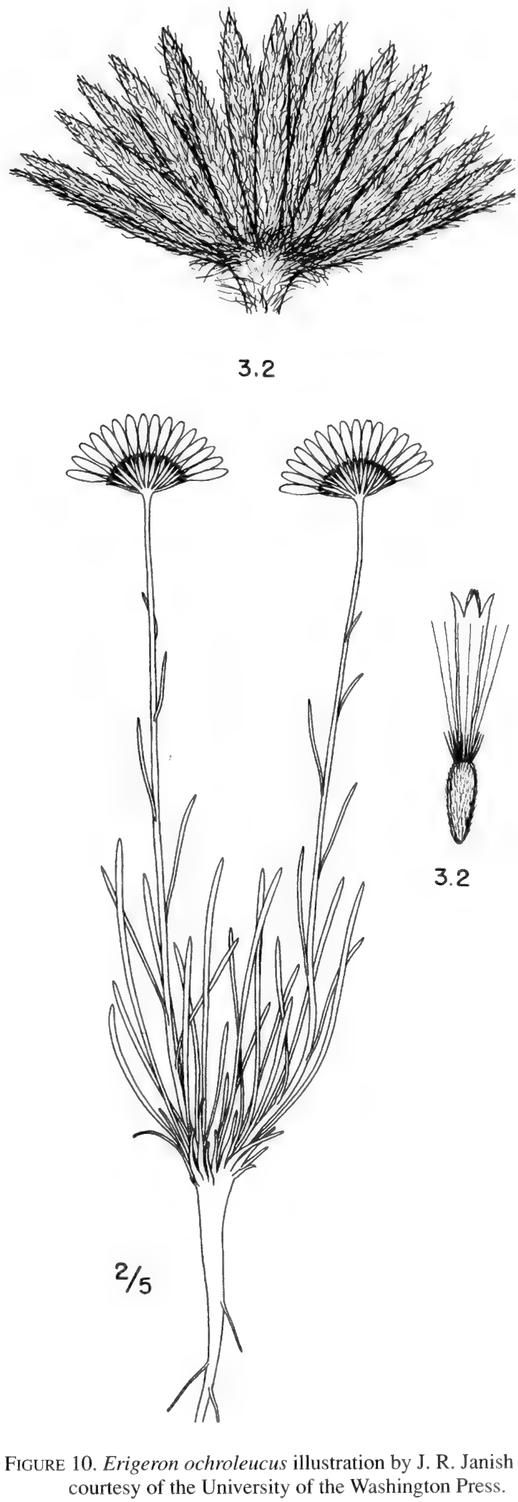


FIGURE 10. *Erigeron ochroleucus* illustration by J. R. Janish courtesy of the University of the Washington Press.

FIGURE 11. *Saussurea nuda* photo credit B. Bennett.

1b. Phyllaries strongly unequal, the other ovate to lanceolata, conspicuously shorter than inner; receptacles scaly; heads 3-20+ in corymbiform to subcapitate arrays. . . . . *S. angustifolia*

Sonchus oleraceus L., Common Sow-thistle – (Deletion – I)

This was reported in Cody et al. (2000) from Beaver River Hot Springs *B. A. Bennett 98-334*. However, the collection has been revised to *Lactuca biennis*. Additionally *S. oleraceus* ssp. *uliginosus* was mapped in the addendum of Cody (2000) in the Labiche Valley, southeast Yukon. This should correctly read *S. arvensis* ssp. *uliginosus*.

Symphyotrichum laeve (L.) A. & D. Löve var. *geyeri* (Gray) Nesom (*Aster laevis* L. ssp. *geyeri* (A.Gray) Piper), Smooth Blue American-Aster – (Deletion – N)

The specimen cited by Cody (1994) has been revised (see below).

†*Symphyotrichum subspicatum* (Nees) Nesom var. *subspicatum* (*Aster subspicatus* Nees), Leafy-bract American-Aster – (Addition – N)

Aster laevis was first reported in Cody (1994). A supporting specimen was collected at Marsh Lake, 60°31'N 134°20'W, *S. Harris sn* (UAC – photocopy DAO). This specimen has since been revised to *Symphyotrichum subspicatum*. An additional collection identified as *A. laevis* was reported from the edge of willows on west side of Haines Road, 25 km south of Haines Junction, *R. Whitcus 1654*, 5 August 1979 (ALTA) was revised to *Solidago multiradiata* Aiton by B. A. Bennett with the note "unusually tall likely due to growing in the shade of the willows."

†*Taraxacum hyparcticum* Dalst., Northern Dandelion – (Addition – N)

This species is known both to the west in scattered localities in Alaska and to the east throughout the Northwest Territories and Nunavut; the nearest known locality being in the vicinity of Inuvik 350 km to the southeast.

Specimens examined: Ptarmigan Bay, Ivvavik National Park, where it was rare, only place found on 10° north-facing slope, 50% gravelly sandy silt on long linear frost boils with *Taraxacum alaskanum, Salix arctica, Primula borealis* and *Trisetum spicatum*. Approximately 80 plants seen flowering, many more not flowering, flowers appear pinkish with the backs with a bluish tinge which may only be visible to most under ultra-violet light, 69.488°N 139.087°W, 20 m, *B. A. Bennett & C. L. Parker 05-0723,* 5 August 2005 (ALA, DAO, MT) (determined by C. L. Parker). It can be distinguished from other species of *Taraxacum* in Yukon as follows (adapted from Brouillet 2006):

1a. Calyculus bractlets horned. 2
2a. Corollas cream-coloured to white or pink distally, outer abaxially pinkish-striped, low growing 5-12 cm, flowers comparatively large and open. . . . . *T. hyparcticum*
2b. Corollas yellow, drying cream to whitish, plants taller 6-50 cm. . . . . *T. ceratophorum*

Acknowledgments

We thank: Jacques Cayouette for identification of *Carex mackenziei* and confirmation of *Carex × flavicans*; Adolf Ceska for identification of *Carex xerantica* and *Crepis capillaris*; Leslie Cody for the many hours entering this information on her computer: Laurie Consaul for confirmation of *Puccinellia tenella*; Stephen Darbyshire for review of *Agrostis filiculmis*; Reidar Elven for confirmation of *Silene soczavana* var. *macrosperma* and *Saxifraga rivularis* ssp. *arctolitoralis*; Don Farrar and Mary Stensvold for the identification of *Botrychium* specimens; Marc Garneau for revision of *Elatine triandra*; David F. Murray for the identification of *Potentilla crebridens* and *Silene soczavana* var. *macrosperma*; Terry McIntosh for reviewing an earlier draft of this paper. Michael J. Oldham for identification of *Carex rariflora* var. *androgyna*; Carolyn L. Parker for confirmation of *Carex microchaeta* ssp. *nesophila* and identification of *Taraxacum hyparcticum*; Paul Petersen and Beata Paszko for the confirmation of *Calamagrostis holmii*; A. A. (Tony) Reznicek for identification of several species of *Carex*; Charles J. Sheviak for identification of *Platanthera* (*Limnorchis*) *huronensis*; and Peter Zika for advice on identification of *Impatiens.*

Documents Cited (marked * in text)

COSEWIC. 2005. Committee on the Status of Endangered Wildlife in Canada. http://www.cosewic.gc.ca.

Farrar, D. R. 2003. Key to western species of moonwort ferns (*Botrychium* subgenus *Botrychium*). Unpublished key.

Farrar, D. R. 2006. Moonwort (*Botrychium*) Systematics, Ada Hayden Herbarium. www.public.iastate.edu/~herbarium/botrychium.html.

Reznicek, A. A. 2003. Alaska *Eleocharis* key. Alaska Cyperaceae Workshop. Fairbanks, Alaska. Unpublished key.

Stensvold, M., and **D. R. Farrar.** 2008. Moonwort fern surveys in the Wrangell-St. Elias Mountains and genetic analysis with an emphasis on *Botrychium tunux* & *Botrychium lineare*. Unpublished report, US Fish and Wildlife Service, Anchorage, Alaska. 24 pages.

Yukon Conservation Data Centre. 2009. NatureServe Explorer: An online encyclopedia of the (web application). Version 6.2. NatureServe, Arlington, Virginia. http://www.natureserve.org/explorer.

University of Alaska, Museum of the North. 2009, Arctos database. http://arctos.database.museum/SpecimenResults.cfm. Accessed 13 December 2009. Fairbanks, Alaska.

Literature Cited

Ball, P. W. 2002. 26t. *Carex* Linnaeus sect. *Limosae* Pages 416-419 *in* The Flora of North America. Volume 23. Magnoliophyta: Commelinidae [in part]: Cyperaceae. Oxford University Press, New York.

Barkworth, M. E. 2007. 14.26 *Deschampsia* P. Beauv. Pages 624-633 *in* The Flora of North America. Volume 24. Magnoliophyta: Commelinidae [in part]: Poaceae, part 1. *Edited by* The Flora of North America Editorial Committee. Oxford University Press, New York.

Baum, B. R. 2007. 14.52 *Avena* L. Pages 734-739 *in* The Flora of North America. Volume 24. Magnoliophyta: Commelinidae [in part]: Poaceae, part 1. *Edited by* the Flora of North America Editorial Committee. Oxford University Press, New York.

Boivin, B. 1968. Flora of the Prairie Provinces Part II. Provancheria 3. Hierbier Louis-Marie, Université Laval, Québec, pages 219-339.

Brouillet, L. 2006. 37. *Taraxacum* F. H. Wiggers, Pages. 239-252 *in* The Flora of North America. *Edited by* The Flora of North America Editorial Committee. Volume 19, Magnoliophyta: Asteridae [in part]: Asterceae, part 1. Oxford University Press, New York.

Carlson, M. L., and **M. Shepherd.** 2007. Is the spread of non-native plants in Alaska accelerating? USDA General Technical Report. PNW-GTR-694. Pages 117-133.

Catling, P. M. 2005. Identification and distribution of the small white water-lilies, *Nymphaea tetragona* and *N. leibergii*, in Northwest Territories. Botanical Electronic News 348: 1-2.

Cayouette, J. [*in press*]. The *Carex* flora of Quebec-Labrador north of 54°N *in* Sedges, uses, diversity, and systematics of the Cyperaceae. Naczi. *Edited by* R. F. C. and B. A. Ford. Monographs in Systematic Botany, Missouri Botanical Garden.

Cayouette, J., and **P. M. Catling.** 1992. Hybridization in the genus *Carex* with special reference to North America. Botanical Review 58: 351-438.

Cody, W. J. 1956. New plant records for northern Alberta and southern Mackenzie District, N.W.T. Canadian Field-Naturalist 68(3): 110-117.

Cody, W. J. 1961. New plant records from the Upper Mackenzie River Valley, Mackenzie District, Northwest Territories. Canadian Field-Naturalist 75(2): 55-69.

Cody, W. J. 1994. The flora of the Yukon Territory: Additions, range extensions and comments. Canadian Field-Naturalist 108(4): 428-476.

Cody, W. J. 1996. Flora of the Yukon Territory. NRC Research Press, Ottawa, Ontario, Canada. 643 pages.

Cody, W. J. 2000. Flora of the Yukon Territory. Second Edition. NRC Research Press, Ottawa, Ontario, Canada. 669 pages.

Cody, W. J., B. Bennett, and **P. Caswell.** 2005. New records of Vascular Plants in the Yukon Territory VII. Canadian Field-Naturalist 119(3): 417-436.

Cody, W. J., C. E. Kennedy, and **B. Bennett.** 1998. New Records of Vascular Plants in the Yukon Territory. Canadian Field-Naturalist 112(2): 289-328.

Cody, W. J., C. E. Kennedy, and **B. Bennett.** 2000. New Records of Vascular Plants in the Yukon Territory II. Canadian Field-Naturalist 114(3): 417-443.

Cody, W. J., C. E. Kennedy, and **B. Bennett.** 2001. New Records of Vascular Plants in the Yukon Territory III. Canadian Field-Naturalist 115(2): 301-322.

Cody, W. J., C. E. Kennedy, B. Bennett, and **V. Loewen.** 2002. New Records of Vascular Plants in the Yukon Territory IV. Canadian Field-Naturalist 116(3): 446-474.

Cody, W. J., C. E. Kennedy, B. Bennett, and **J. Staniforth.** 2003. New Records of Vascular Plants in the Yukon Territory V. Canadian Field-Naturalist 117(2): 278-301.

Cody, W. J., C. E. Kennedy, B. Bennett, and **P. Caswell.** 2004. New records of Vascular Plants in the Yukon Territory VI. Canadian Field-Naturalist 118(4): 558-578.

Costea, M., F. J. Tardif, and **H. R. Hinds.** 2005. 30. *Polygonum* Linnaeus pages. Pages 547-571 *in* The Flora of North America. Volume 5, Magnoliophyta: Caryophyllidae, part 2. *Edited by* The Flora of North America Editorial Committee. Oxford University Press, New York.

Douglas, G. W., G. W. Argus, H. L. Dickson, and **D. F. Brunton.** 1981. The rare vascular plants of the Yukon. Syllogeus 28: 1-96.

Douglas, G. W., D. Meidinger, and **J. Pojar.** 1999a. Illustrated Flora of British Columbia Volume 3. Dicotyledons (Diapensiaceae through Onagraceae). Ministry of the Environment, Lands and Parks, British Columbia Ministry of Forests, Victoria, British Columbia. 423 pages.

Douglas, G. W., D. Meidinger, and **J. Pojar.** 1999b. Illustrated Flora of British Columbia Volume 4. Dicotyledons (Orobanchaceae through Rubiaceae). Ministry of the Environment, Lands and Parks, British Columbia Ministry of Forests, Victoria, British Columbia. 427 pages.

Douglas, G. W., D. Meidinger, and **J. Pojar.** 2000. Illustrated Flora of British Columbia Volume 5. Dicotyledons (Salicaceae through Zygophyllaceae. Ministry of the Environment, Lands and Parks, British Columbia Ministry of Forests, Victoria, British Columbia. 389 pages.

Douglas, G. W., D. Meidinger, and **J. Pojar**. 2002. Illustrated Flora of British Columbia Volume 8. General Summary, Maps and Keys. Ministry of the Environment, Lands and Parks, British Columbia Ministry of Forests, Victoria, British Columbia.

Douglas, G. W., G. B. Straley, D. Meidinger, and **J. Pojar.** 1998a. Illustrated Flora of British Columbia Volume 2. Gymnosperms and Dicotyledons (Aceraceae through Asteraceae). Ministry of the Environment, Lands and Parks, British Columbia Ministry of Forests, Victoria, British Columbia. 436 pages.

Douglas, G. W., G. B. Straley, D. Meidinger, and **J. Pojar.** 1998b. Illustrated Flora of British Columbia Volume 2. Dicotyledons (Balsaminaceae through Cuscutaceae). Ministry of the Environment, Lands and Parks, British Columbia Ministry of Forests, Victoria, British Columbia. 401 pages.

Elven, R., and **D. F. Murray.** 2008a. New combinations in the Panarctic vascular plant flora. Jounal of the Botanical Research Institute of Texas 2(1): 433-446.

Elven, R., and **D. F. Murray.** 2008b. The *Potentilla nivea* group in northwestern North America. Botanical Electronic News. 389. www.ou.edu/cas/botany-micro/ben.

Holmgren, P. K., and **N. H. Holmgren.** 1998 onwards (continuously updated). Index Herbariorum. New York Botanical Garden. Available at: http://sciweb.nybg.org/science2/IndexHerbariorum.asp.

Hultén, E. 1950. Flora of Alaska and Yukon. X. Lunds Universitets Ny Följd Afdelningen 2, Band 45, Nr. 1: 1485-1902.

Hultén, E. 1968. Flora of Alaska and Neighboring Territories. Standford University Press. Standford, California, USA. 1008 pages.

Jørgensen, M. H., R. Elven, A. Tribsch, T. M. Gabrielsen, B. Stedje, and **C. Brochmann.** 2006. Taxonomy and evolutionary relationships in the *Saxifraga rivularis* complex. Systematic Botany 31(4): 702-729.

Keil, D. J. 2006. 15. *Saussurea* de Candolle. Pages 165-168 *in* The Flora of North America. Volume 19. Magnoliophyta: *Asteridae* (in part): Asteraceae, part 1. Oxford University Press, New York.

Klinkenberg, B. *Editor.* 2009. E-Flora BC: Electronic Atlas of the Plants of British Columbia (eflora.bc.ca). Lab for Advanced Spatial Analysis, Department of Geography, University of British Columbia, Vancouver, 13 December 2009.

Marr, K. L., R. J. Hebda, and **C. W. Greene.** 2007. 14.49 *Calamagrostis* Adans. Pages 706-732 *in* Flora of North America. Volume 24. Magnoliophyta: Commelinidae (in part): Poaceae, part 1. *Edited by* the Flora of North America Editorial Committee. Oxford University Press, New York.

Mastroguiseppe, J., P. E. Rothrock, A. C. Dibble, and **A. A. Reznicek.** 2002. 26q. *Carex* Linnaeus sect. *Ovales* Kunth, Pages 332-378 *in* The Flora of North America. Volume 23. Magnoliophyta: Commelinidae (in part): Cyperaceae. *Edited by* the Flora of North America Editorial Committee. Oxford University Press, New York.

McJannet, C. L., G. W. Argus, and **W. J. Cody.** 1995. The rare vascular plants in the Northwest Territories. Syllogeus 73, Canadian Museum of Nature. 104 pages.

Mitchell, W. W. 1967. Taxonomic synopsis of *Bromus* section *Bromopsis* (Gramineae) in Alaska. Canadian Journal of Botany 45: 1309-1313.

Morton, J. K. 2005. *Silene* Linnaeus. Pages 166-214 *in* The Flora of North America. Volume 5, Magnoliophyta: Caryophyllidae, part 2. *Edited by* Editorial Committee the Flora of North America. Oxford University Press, New York.

Mosyakin, S. L. 2005. *Rumex* Linnaeus pp. 489-533 *in* The Flora of North America Volume 5, Magnoliophyta: Caryophyllidae, part 2. *Edited by* the Flora of North America Editorial Committee. Oxford University Press, New York.

Murray, D. F. 1970. *Carex podocarpa* and its allies in North America. Canadian. Journal of Botany 48(2): 313-324.

Murray, D. F. 1971. Notes on the alpine flora of the St. Elias Mountains. Arctic 24: 301-304.

Murray, D. F. 2002. 26t. *Carex* Linnaeus sect. *Scitae* Pages 414-416 *in* Flora of North America. Volume 23. Magnoliophyta: Commelinidae (in part): Cyperaceae. *Edited by* the Flora of North America Editorial Committee.Oxford University Press, New York.

Nesom, G. L. 2006. 186. *Erigeron* Linnaeus. Pages 256-348 in The Flora of North America, *Volume 20,* Magnoliophyta: Asteridae (in part), part 8*:* Asteraceae, part 2. *Edited by* the Flora of North America Editorial Committee. Oxford University Press, New York.

Nesom, G. L., and **D. F. Murray.** 2004. Notes on North American arctic and boreal species of *Erigeron* (Asteraceae: Astereae). Sida 21(1): 41-57.

Pavlick, L. E. 1995. *Bromus* L. Royal British Columbia Museum, Victoria. 180 pages.

Pavlick, L. E., and **L. K. Anderton.** 2007. 12.01 *Bromus* L. Pages 193-237 *in* The Flora of North America Volume 24, Magnoliophyta: Commelinidae (in part): Poaceae, part 1. *Edited by* the Flora of North America Editorial Committee. Oxford University Press, New York.

Porsild, A. E. 1943. Materials for a flora of the continental Northwest Territories of Canada. Sargentia 4. 71 pages.

Porsild, A. E. 1951. Botany of Southeastern Yukon Adjacent to the Canol Road. National Museum of Canada Bulletin 121. 400 pages.

Porsild, A. E. 1966. Contributions to the flora of southwestern Yukon Territory. National Museum of Canada Bulletin 216: 1-86.

Porsild, A. E. 1975. Materials for a flora of central Yukon Territory. National Museums of Canada, National Museum of Natural Sciences Publications in Botany 4. 77 pages.

Porsild, A. E., and **W. J. Cody.** 1980. Vascular plants of the Continental Northwest Territories, Canada. National Museums of Canada, National Museum of Natural Science, Ottawa, Ontario. 667 pages.

Reznicek, A. A. 2002. 26t. *Carex* Linnaeus sect. *Foetidae* Pages 309-311 *in* Flora of North America. Volume 23. Magnoliophyta: Commelinidae (in part): Cyperaceae. *Edited by* the Flora of North America Editorial Committee. Oxford University Press, New York.

Rydberg, P. A. 1900. Catalogue of the flora of Montana and the Yellowstone National Park. Memoir of the New York Botanical. Gardens 1:vi–xii.1–492.

Saarela, J. M. 2008. Taxonomy of Bromus (Poaceae: Pooideae: Bromeae) sections *Bromopsis*, *Bromus*, and *Genea* in British Columbia, Canada. Journal of the Botanical Research. Institute of Texas 2: 323-372.

Saarela, J. M. 2009. Taxonomy of Bromus sections *Bromus*, *Bromopsis* and *Genea* (Poaceae) in British Columbia: A Summary, a key, new records, specimen citations, and miscellaneous notes. Botanical Electronic News. 415. http://www.ou.edu/cas/botany-micro/ben/ben415.

Sears, C. J. 2008. Morphological discrimination of *Platanthera aquilonis*, *P. huronensis*, and *P. dilatata* (Orchidaceae) herbarium specimens. Rhodora. 110(944): 389-405.

Sheviak, C. J. 1999. The identities of *Platanthera hyperborea* and *P. huronensis*, with the description of a new species from North America. Lindleyana. 14(4): 193-203.

Sheviak, C. J. 2002. 26. *Platanthera* Richard, De Orchid. Pages 551-571 *in* The Flora of North America. Volume 26, Magnoliophyta: Liliidae. *Edited by* the Flora of North America Editorial Committee. Oxford University Press, New York.

Shultz, L. M. 2006. 119. *Artemisia* Linnaeus, Pages. 503-534 *in* The Flora of North America. Flora of North America. Volume 19, Magnoliophyta: Asteridae (in part): Asterceae, part 1. *Edited by* the Flora of North America Editorial Committee. Oxford University Press, New York.

Smith, S. G., J. J. Bruhl, M. S. González-Elizondo, and **F. J. Menapace.** 2002. 8. *Eleocharis* R. Brown. Pages 60-120 *in* The Flora of North America. Volume 23. Magnoliophyta: Commelinidae (in part): Cyperaceae. *Edited by* the Flora of North America Editorial Committee. Oxford University Press, New York.

Standley, L. A., J. Cayouette, and **L. Bruederle.** 2002. 26r. *Carex* Linnaeus sect. *Phacocyctis* Pages 379-401 *in* The Flora of North America. Volume 23. Magnoliophyta: Commelinidae (in part): Cyperaceae. *Edited by* the Flora of North America Editorial Committee. Oxford University Press, New York.

Taylor, R. L., and **B. MacBryde.** 1977. Vascular plants of British Columbia. Botanical Gardens Technical Bulletin Number.4. UBC Press. Vancouver, British Columbia. 754 pages.

Toivonen, H. 2002. 26m. *Carex* Linnaeus sect. Glareosae. Pages 311-321 *in* The Flora of North America. Volume 23. Magnoliophyta: Commelinidae (in part): Cyperaceae. *Edited by* the Flora of North America Editorial Committee. Oxford University Press, New York.

Tolmachev, A. I., J. G. Packer, and **G. C. D. Griffiths.** 1995. Flora of the Russian Arctic Volume I *Polypodiaceae – Gramineae*. University of Alberta Press, Edmonton. Alberta, 303 pages.

Wagner, W. H. Jr., and **J. R. Grant.** 2002. *Botrychium alaskense*, a new moonwort from the interior of Alaska. American Fern Journal 92(2): 164-170.

Welsh, S. L. 1974. Anderson's Flora of Alaska and Adjacent Parts of Canada. Brigham Young University Press, Provo, Utah, U.S.A. 724 pages.

Yurtsev, B. A. 1984. Flora Arctica USSR. IX, 1. Droseraceae – Rosaceae. Nauka, Leningrad.

Zika, P. 2009. Jewelweeds and touch-me-nots (*Impatiens*, Balsaminaceae) in the Pacific Northwest of North America. Botanical Electronic News 408: 2-6, + 14 figures. http://www.ou.edu/cas/botany-micro/ben/ben408.html#3http://bomi.ou.edu/ben/408/impatiens_figures_408.pdf

Received 27 January 2010
Accepted 2 March 2010

Interspecific Mate Choice and Hybridism in the Bufflehead, *Bucephala albeola*

James K. Finley[1] and Suzanne Huot[2]

[1] 10232 Summerset Place, Sidney, British Columbia V8L 4X2 Canada; corresponding author: jameskfinley@telus.net
[2] Cloake Hill Road, North Saanich, British Columbia V8L 5J9 Canada; suzannenaturephoto@shaw.ca

Finley, James K., and Suzanne Huot. 2010. Interspecific mate choice and hybridism in the Bufflehead, *Bucephala albeola*. Canadian Field-Naturalist 124(1): 28–31.

Observations of a male Bufflehead (*Bucephela albeola*) paired with a female Common Goldeneye (*Bucephela clangula*) in northern Alberta in 1995 and of a hybrid male Common Goldeneye × Bufflehead photographed near Victoria, British Columbia, in March 2009 provide the first combined evidence of interspecific mate choice and out-crossing in *Bucephala albeola*. Since 1999, there have been at least 10 unofficial records, including photographs, of Common Goldeneye × Bufflehead hybrids posted on the Internet, as well as 6 records of hybridization with Hooded Mergansers (*Lophodytes cucullatus*). In all cases, where evident in Common Goldeneye × Buffleheads, gold eyes and pink feet were expressed and social affiliation was with Common Goldeneyes, suggesting matrilineage with that species. Because most attention is given to the hybrid—and to male hybrids at that—rather than to the progenitors, the theory of mate attraction, through sexual imprinting of males, is biased toward the paternal viewpoint. It appears that there is more plasticity in mate choice, particularly by the female. The opportunity to observe mate choice is much rarer than the hybrid outcome, while the odds of the latter have increased many fold in the last decade due to advances in Internet communication and digital photography. This exercise illustrates the ability of the Internet to amplify the prevalence of rare phenomena many fold over historical records.

Key Words: Sea ducks, Mergini, Bufflehead, *Bucephala albeola*, goldeneyes, *Bucephala* spp., interspecific mate choice, hybridism, British Columbia.

In his monograph on Buffleheads (*Bucephala albeola*), Erskine (1972: 196) stated that "The bufflehead is distinctly a North American duck, but it is one of a group of species which extend right around the Northern Hemisphere and which are collectively referred to as the seaducks [the Mergini tribe] since they commonly winter on saltwater." The seaducks, or Mergini tribe, is a motley tribe, consisting of four closely related Palearctic genera, each with three species – the *Bucephala* genus including Common Goldeneye (*Bucephala clangula*), Barrow's Goldeneye (*B. islandica*), and Bufflehead; the scoters (*Melanitta* spp.); the mergansers (*Mergus* spp. and *Lophodytes cucullatus*); and the eiders (*Somateria* spp. and *Polysticta stelleri*). Many of these ducks are noted for their distinctive facial badges. At the time Erskine was writing his monograph, there were no known hybrids of Buffleheads, although in the delay between writing and publication, Erskine did learn of a putative hybrid with a goldeneye (*Bucephala* sp.).

The Bufflehead is the smallest of the three goldeneyes, and it faces competition for nesting cavities, strong aggression, and even infanticide from female goldeneyes. The goldeneyes are most closely related to the mergansers, and there are several records of hybrids between the Common Goldeneye and the Hooded Merganser (*Lophodytes cucullatus*) in North America and with the Smew (*Mergus albellus*) in Europe (Johnsgard 1965). In contrast, Gauthier (1993) noted that there were only two putative cases of out-crossing of the Bufflehead: a possible cross with a goldeneye from a wing sample in Ontario and a sighting of a presumed cross with a Hooded Merganser in Illinois.

The Bufflehead's small size, its specialized niche in tree-cavity nesting, distinctive courtship display, and strong competition with its closest cousins, the goldeneyes, make interbreeding unlikely. Given the vast and fairly remote breeding habitat of goldeneyes, it would be even less likely for anyone to observe such aberrant pairing; it is more likely that the hybrid itself would be seen on the wintering grounds. Thus, given the state of knowledge at the turn of this century, one would not have expected to encounter either a mixed pair or their offspring in a lifetime. JKF has been fortunate to have seen both cases. What began as a simple anecdote has turned into a short essay on the nature of hybridism.

Observations

On 20 May 1995, as JKF crossed over a small bridge on a stream flowing out of Swan Lake (55°31'33"N, 120°01'55"W), 35 km south of Dawson Creek, British Columbia, he glimpsed a Bufflehead drake hauled out on a log in close company with a Common Goldeneye hen. Because it was close to a provincial park campground, he was able to observe the pair over the next two days. Clearly they were paired, and the female goldeneye occupied a nest cavity in a Balsam Poplar (*Populus balsamifera*), visible from the bridge. When she was in the nest, the Bufflehead remained close by, and he joined her when she left. Judging from the hen's behaviour, egg laying was well under way. Attempts to

photograph the pair were unsuccessful and when disturbed they flew to the nearby lake, which was occupied by at least 20 Common Goldeneyes, many in courtship.

The incident was intriguing, since the goldeneye had plenty of her kind to choose from. Meanwhile, because both species occupied winter habitat in front of JKF's home on Shoal Harbour Migratory Bird Sanctuary, JKF began to study Bufflehead behaviour in earnest (Finley 2007a, 2007b), as well as on their breeding grounds in the interior grasslands of British Columbia. JKF presumed that the opportunity to verify his earlier observations of pair-bonding was highly unlikely.

JKF was surprised then, when on 21 March 2009, SH called him and asked whether he had ever heard of a Bufflehead × goldeneye cross. She was certain that she'd just photographed such a bird in Esquimalt Lagoon Migratory Bird Sanctuary, near Victoria (48.43°N, 123.47°W). She forwarded several images, and had indeed taken a photograph of a male hybrid *Bucephala albeola* × *B. clangula* (Figure 1). Most notable was the distinctive white head patch, a combination of both species. Features that were clearly Bufflehead included its head shape, white scapular plumage, pink feet, blue-grey bill, and greyish tail. Common Goldeneye attributes included its yellow eye, green iridescence, larger bill, and its "head-throw" courting posture.

On the following day, JKF observed the bird closely amongst a frenzy of Mallards (*Anas platyrhynchos*), Northern Pintails (*Anas acuta*), Greater Scaup (*Aythya marila*), Common Goldeneyes, and Buffleheads being fed grain by an elderly couple. They said that the hybrid had been present for at least two or three weeks and that it usually appeared during their regular noon feeding sessions, and associated with the goldeneyes. The goldeneyes and Buffleheads were diving beneath the large flock of puddle ducks and surfacing at the periphery, but the hybrid bird acted differently, surfacing only for brief moments. When feeding subsided, it surfaced with the goldeneyes. It had the look and behaviour of a goldeneye, intermediate in size, tending toward the larger. Initially it remained with the goldeneyes (males and females), then swam offshore and slept by itself. Afterwards, it approached a small group of Buffleheads, but there was no interaction, and once again it swam off by itself. Its dive posture and flight were goldeneye in character. JKF's impression was that the hybrid was shunned by both sides, although it favoured association with goldeneyes, suggesting that it had been raised as one, in an arrangement like the one JKF had seen 14 years earlier.

Discussion

This represents the first documented case of interspecific pair-bonding and out-crossing of the Bufflehead with the Common Goldeneye (Johnsgard 1960, 1965; Bellrose 1976; Gauthier 1993; Gillham and Gillham 2002). Hybridization of the Common Goldeneye has been reported with Barrow's Goldeneye, White-winged Scoter (*Melanitta fusca*), Common Merganser (*Mergus merganser*) and Hooded Merganser, and Smew (Johnsgard 1965). Because the Bufflehead and Common Goldeneye occupy similar habitats and the dichromatic patterns of the chicks are nearly identical, one might expect that hybridization of the Bufflehead would occur more often. However, because they are so similar and there is such fierce competition with goldeneyes, one would expect such animosity to suppress mutual attraction. Furthermore, although hybridization occurs much more frequently amongst waterfowl than any other family (Johnsgard 1960; Tubaro and Lijtmaer 2002) and monogamy tends to be the family rule, Mayr (1942) found that hybrids occurred much more rarely among monogamous species. And Buffleheads are strongly monogamous, with a ritualized courtship display very different from that of the Common Goldeneye. So what happens on rare occasions?

FIGURE 1. Hybrid Bufflehead × Common Goldeneye drake showing Common Goldeneye "head toss" courtship display, Esquimalt Lagoon Migratory Bird Sanctuary, 21 March 2009. (Photograph ©Suzanne Huot)

Half of the explanation for interspecific attraction could be cross-fostering of Buffleheads by Common Goldeneyes and imprinting of the males. Experiments in cross-fostering in domestic waterfowl show that only the males imprint on the other species (Welty 1975; Randler 2005, 2006). In species in which only the female cares for the young, female imprinting would be counter-productive. Females have an innate preference for the colour patterns, calls, and courtship displays of the male. Thus, although the paternal side of the hybrid is explicable, it remains a mystery how the female goldeneye forsook her own species and fell for the charms of a diminutive (though very dapper) cousin, particularly when she had plenty of her own kind to choose from.

Several years ago, JKF rescued a juvenile male Bufflehead from a predator and kept it over the winter with a white female domestic Call Duck *(Anas*

TABLE 1. Records of Bufflehead hybrids posted on the Internet in the last decade. Not an exhaustive list.

Date observed	Location	Observer	Photo	Comments
Common Goldeneye × Bufflehead				
Monday 1 March 1999	Weber Canyon, Utah	A. Smith	yes	
Tuesday 15 April 2003	Denman Island, B.C.	M. Kirk	no	
Saturday 20 November 2004	Port Alberni, B.C.	M. McRuer	yes	
Monday 29 November 2004	Weber Canyon, Utah	K. Purdy	yes	# documented records to 5
Friday 25 February 2005	Burlington, Ont.	B. Holden	yes	
? April 2005	Ontario	McLaughlin	?	Ontario Birds 23(1)
? February 2007	Laval, Que.	P. Bannon	?	The Song Sparrow 49(4)
Saturday 8 December 2007	Columbia River, Wash.	B. La Framboise	yes	
? March 2008	Walla Walla, Wash.	D. St. George	yes	Returning for last 3 or 4 years
Friday 28 November 2008	Lake Solano, Calif.	G. Ewing	yes	
Wednesday 2 December 2009	Esquimalt, B.C.	?	yes	Same bird as seen in the winter of 2008-09
Friday 1 January 2010	Lake Solano, Calif.	E. Harper	yes	Same bird as seen in 2008
Hooded Merganser × Bufflehead				
Sunday 4 May 1980	Powderhorn Marsh, Ill.	W. Marcisz	yes	Paired with female Bufflehead
Friday 8 December 2006	Berkeley Marina, Calif.	B. Battagin	yes	
Sunday 6 January 2008	Bronte Harbour, Ont.	M. Boyd	no	
Sunday 27 December 2009	Mississauga, Ont.	C. Wood	yes	
Sunday 17 January 2010	Cleveland, Ohio	ammodrammus	yes	
Wednesday 10 March 2010	Central coast, Texas	M. O'Brien	no	

platyrhynchos). They formed a strong pair bond, and although intercourse was not observed, the hen laid and incubated a clutch that proved infertile. When JKF attempted to break up the relationship and release the drake, the Call Duck became distressed and abandoned her clutch. When they were reunited after several days, they greeted each other with evident affection. When JKF released them in the male's natal territory and while he was handling the female, causing distress, the Bufflehead came to her defense, biting his hand and cuffing it with his wings. They remained closely bonded in the wild for a few days; then the female was taken by a predator. It would seem that there is a lot more latitude for individuality in mate choice, not only by the female. This pairing indicated that the "look of love" could bridge a major tribal barrier—Mergini to Anatini.

Hybrids are of special interest to evolutionary biologists (Mayr 1942; Randler 2005, 2008; Tubaro and Lijtmaer 2002), and hybrid waterfowl, because of their striking plumage patterns, are amongst the most studied. Long lists of hybrid waterfowl have been compiled (Gillham and Gillham 2002). Most sightings are from their wintering grounds, and the majority are males. Because waterfowl are widely dispersed and inaccessible in their northern breeding grounds, opportunities to observe the actual parents of hybrids are limited. Therefore, practically all analyses and interpretation of the nature of hybridism are based on the hybrid itself and not the parents. Moreover, attention is focused almost exclusively on male hybrids. This gives a limited understanding, particularly if cross-fostering and sex-specific imprinting are two of the leading factors behind hybridism.

Recent sightings and photographs posted on the Internet

Although JKF was familiar with the scientific literature on the subject and conducted a "Google scholar" search, it wasn't until after he had submitted the first draft of this manuscript that he found several postings about hybrid Buffleheads on the Internet, including one concerning the same bird that SH photographed, in the following winter. Eventually JKF compiled a list of 18 records of Bufflehead hybrids from various Internet sites, such as flickr (**www.flickr.com**, a website used to manage and share photos) and eBird (ebird.org, an online checklist website developed by the Cornell Lab of Ornithology and the National Audubon Society and hosted by Cornell). Most records are from the last few years (Table 1). Two thirds (12) of the records were Common Goldeneye × Buffleheads, including two or three duplicate records. All others were Hooded Merganser × Buffleheads. Except for an apparent female Hooded Merganser × Bufflehead, all other hybrids were males.

In all cases, where it was evident, compared to the Esquimalt bird, the gold eye (subdued) of one species and the pink feet of the other were expressed. The most distinctive variant feature was the shape and extent of the face patch, one of the most distinctive badges of the Mergini tribe. In all cases, where it was apparent, the Common Goldeneye × Bufflehead hybrids were associated with Common Goldeneyes.

In several cases, the hybrids had returned to the same location, year after year, and had become attractions on local birding hotlines. Most of the Common Goldeneye × Buffleheads have been reported from western North America, whereas most of the observations of Hooded Merganser × Buffleheads came from eastern North America. Evidently, hybridism of Buffleheads occurs on a regular but extremely rare basis, and in at least one case—a male Hooded Merganser × Bufflehead hybrid paired with a female Bufflehead—it appears that merganser genes are being passed back into the Bucephala pool.

This exercise attests to the power of the Internet in conjunction with digital photography and the rising popularity of bird watching. There has been an exponential increase in sightings of hybrids that are not being documented as they once were in the scientific literature. With audience fragmentation, the recorded natural history anecdote has become both a victim and beneficiary of the Internet revolution. The large increase in sightings in the last decade compared to all of the previous century is a cultural artifact and not a statistical trend. It demonstrates the power of the Internet to amplify the prevalence of rare phenomena and cautions us about jumping to conclusions regarding the rate of change.

Acknowledgments

My appreciation is extended to the reviewers, A. J. Erskine and C. S. Houston, and my wife, Laura, for their comments. In memory of Buferd and Bella.

Literature Cited

Bellrose, F. C. 1976. Ducks, geese and swans of North America. Second edition. Stackpole Books, Harrisburg, Pennsylvania. 544 pages.

Erskine, A. J. 1972. Buffleheads. Canadian Wildlife Service Monograph Series (4). Information Canada, Ottawa. 240 pages.

Finley, J. K. 2007a. The punctual Bufflehead: autumn arrivals in Shoal Harbour Sanctuary, Vancouver Island in relation to freeze-up. Canadian Field-Naturalist 122: 370-374.

Finley, J. K. 2007b. Offshore flight of Buffleheads (*Bucephala albeola*) after twilight in winter: an anti-predation tactic? Canadian Field-Naturalist 122: 375-378.

Gauthier, G. 1993. Bufflehead, *Bucephala albeola*. The Birds of North America no. 67. *Edited by* A. Poole and F. Gill, The Academy of Natural Sciences, Philadelphia. 24 pages.

Gillham E., and **B. Gillham.** 2002. Hybrid ducks. The 5th contribution towards an inventory. Published by the authors, Lydd on Sea, Kent. (unpublished, cited by Randler 2005).

Johnsgard, P. A. 1960. Hybridization in the Anatidae and its taxonomic implications. Condor 62: 25-33.

Johnsgard, P. A. 1965. Handbook of waterfowl behavior. Papers in the Biological Sciences, University of Nebraska, Lincoln.

Mayr, E. 1942. Systematics and the origin of species. Columbia University Press, New York.

Randler, C. 2005. Do forced extrapair copulations and interspecific brood amalgamation facilitate natural hybridization in wildfowl? Behaviour 142: 477-488.

Randler, C. 2006. Behavioural and ecological correlates of natural hybridization in birds. Ibis 148: 459-467.

Randler, C. 2008. Hybrid wildfowl in central Europe—an overview. Waterbirds 31: 143-146.

Tubaro, P. L., and **D. A. Lijtmaer.** 2002. Hybridization patterns and the evolution of reproductive isolation in ducks. Biological Journal of the Linnean Society 77: 193-200.

Welty, J. C. 1975. The life of birds. 2nd edition. W. B. Saunders Co., Philadelphia. 623 pages.

Received 26 March 2009
Accepted 26 May 2010

Cetacean Strandings in the Canadian Maritime Provinces, 1990–2008

LEAH NEMIROFF[1], TONYA WIMMER[2], PIERRE-YVES DAOUST[3], and DONALD F. MCALPINE[4]

[1]Biology Department, Dalhousie University, 1355 Oxford Street, Halifax, Nova Scotia B3H 4J1 Canada
[2]Marine Animal Response Society, c/o Nova Scotia Museum, 1747 Summer Street, Halifax, Nova Scotia B3H 3A6 Canada
[3]Canadian Cooperative Wildlife Health Centre, Atlantic Veterinary College, University of Prince Edward Island, 550 University Avenue, Charlottetown, Prince Edward Island C1A 4P3 Canada
[4]New Brunswick Museum, 277 Douglas Avenue, Saint John, New Brunswick E2K 1E5 Canada

Nemiroff, Leah, Tonya Wimmer, Pierre-Yves Daoust, and Donald F. McAlpine. 2010. Cetacean strandings in the Canadian Maritime provinces, 1990–2008. Canadian Field-Naturalist 124(1): 32–44.

Organized cetacean stranding networks function to respond quickly and efficiently to strandings, to coordinate live releases, to gather and analyze data, and to educate the public. Stranding networks in the three Canadian Maritime provinces (New Brunswick, Nova Scotia, and Prince Edward Island) recently cooperated to form the Marine Animal Response Network. The resulting collaborative database provides an opportunity to assess patterns of cetacean strandings encompassing 19 years (1990–2008 inclusive) from across the region. During this period, a total of 640 stranding events involving 19 species and 881individuals of both sexes and varying age groups were reported. Stranding events primarily involved single animals, although several mass strandings were recorded, the largest involving 60 Long-finned Pilot Whales (*Globicephala melas*). The number of strandings was found to vary substantially over time and among the three provinces. In part, this is likely a reflection of differences in local network effort among regions. Most animals were found dead ashore. Entanglement in fishing gear occurred in over 10% of the incidents. Relatively more mysticetes were found dead ashore or at sea and entangled in fishing gear than expected by chance, while more odontocetes were found stranded alive than expected. Harbour Porpoises (*Phocoena phocoena*) appear to be especially vulnerable to entanglement in fishing gear. Necropsies, performed on a subsample of the stranded animals, suggest that Harbour Porpoises die significantly more often from disease than mishap, while Long-finned Pilot Whales and Atlantic White-sided Dolphins (*Lagenorhynchus acutus*) suffer equally from mishap and disease. Refloating was attempted for 23% of animals, with an apparent success rate of 83%, although there are no data on long-term survival. Neither sex nor age of the refloated animals was found to be an indicator of subsequent short-term survival.

Key Words: cetaceans, Atlantic White-sided Dolphin, *Lagenorhynchus acutus,* Harbour Porpoise, *Phocoena phocoena,* Long-finned Pilot Whale, *Globicephala melas,* incidental catch, stranding, Maritimes, Canada.

Cetacean strandings occur on coasts around the world and can range from incidents involving single animals to mass strandings of two or more animals, sometimes involving hundreds of individuals (e.g., Dudok van Heel 1962). Strandings of single animal are the most common, although mass strandings may occur frequently in some regions, and almost exclusively involve odontocetes (Geraci 1978; Sergeant 1982).

The causes of cetacean strandings are still poorly understood; see Brabyn (1991) and Goold et al. (2002) for reviews. Many strandings, especially those of one or two animals, are often attributed to disease, parasitism, or old age (Dailey and Walker 1978; Jauniaux et al. 1997; Evans et al. 2005), entanglement with fishing gear (Félix et al. 1997; Hooker et al. 1997), other injuries (Walsh et al. 1991), or disorientation caused by environmental conditions (Mignucci-Giannoni et al. 1999; Walker et al. 2005). The causes of mass stranding events are even less clear, as they are often complicated by the presence of seemingly healthy individuals within the stranded group (e.g., Brabyn and McLean 1992).

It has been suggested that anthropogenic activities, including military sonar (Simmonds and Lopez-Jurado 1991; Parsons et al. 2000) and seismic activity (Engel et al. 2004), may play a role in cetacean mass strandings by disorienting the animals, increasing stress levels, and inducing gas and fat emboli (Balcomb and Claridge 2001; Fernández et al. 2005). Other possible explanations include coastal topography, such as acoustical "dead zones" that cause odontocete echolocation signals to be severely distorted by geomagnetic effects (Dudok van Heel 1962; Brabyn and McLean 1992; Sundaram et al. 2006); large-scale climatic events (Mignucci-Giannoni et al. 1999); solar and lunar cycles (Vanselow and Ricklefs 2005; Wright 2005); toxicity from pollutants (Bouquegneau et al. 1997; Joiris et al. 1997); and social cohesion (Cordes 1982). Stranding events may also be a consequence of several of these factors acting synergistically (Mignucci-Giannoni et al. 1999; Goold et al. 2002).

An increase in public interest in whales during the last few decades and a desire to study and assist stranded animals have fueled the recent formation of organized stranding networks. Stranding networks exist to provide rapid and effective action in the best interests of live stranded animals, to protect and educate the public, and to gain the maximum amount of scientific information possible from any stranding event (Geraci

and Lounsbury 2005). For some rare cetaceans, most of what is known about the biology of these species has been gleaned from stranded animals (e.g., Kenyon 1961). Ideally, volunteers and paid personnel are trained to respond quickly and effectively to strandings, to coordinate refloating efforts when possible, to collect information, and to provide liaison with the public. Systematic efforts are made to collect, compile, and analyze data from all stranding events.

There are four principal organizations that collect stranding information and participate in refloating attempts in the three Canadian Maritime provinces (Nova Scotia, New Brunswick, and Prince Edward Island): (1) the Marine Animal Response Society (MARS) in Nova Scotia, (2) the New Brunswick Museum, (3) the Grand Manan Whale and Seabird Research Station (GMWSRS) in New Brunswick; and (4) the Atlantic Veterinary College, University of Prince Edward Island. The Marine Animal Response Network of Atlantic Canada (MARNAC) is a cooperative effort among these groups and others.

Data collected by stranding networks may be useful in monitoring the status, distribution, and seasonal abundance of species (e.g., Osborne and Ransom 1988; Ferrero et al. 1994; Evans and Hammond 2004; Norman et al. 2004; Maldini et al. 2005). For instance, in an analysis of 65 years of data collected from both odontocete stranding events and live surveys, Maldini et al. (2005) found that stranding records are a good indicator of species composition and they produce reliable data on the occurrence of species in a region. Information from strandings can also be used to facilitate management by recording unusual mortality events (Le Boeuf et al. 2000; Norman et al. 2000), reporting species previously unidentified in a region (Ferrero and Tsunoda 1989), and monitoring occurrences of human–cetacean interaction (e.g., entanglement and ship strikes) (Gearin et al. 1994; Hooker et al. 1997). Investigation of strandings may also be an effective means of monitoring measures implemented to reduce threats to species (e.g., to monitor changes in the incidence of vessel strikes in areas after shipping lanes have been moved). Samples from strandings also provide valuable information on anatomy and taxonomy, as well as on parasites, dietary habits, toxicology, and reproduction (Hooker et al. 1997; McAlpine et al. 1997; Norman et al. 2004).

Although some significant individual stranding events in the Maritimes have been recorded in the literature (Piers 1923; Mitchell and Kozicki 1975; McAlpine 1985; McAlpine et al. 1997; Lawson and Eddington 1998; McAlpine et al. 1999; McAlpine and Rae 1999), little comprehensive information on cetacean strandings in the region has been published. Hooker et al. (1997) provided a summary of the cetacean strandings in Nova Scotia covering the period 1991–1996, and Lucas and Hooker (2000) reviewed stranding events on Sable Island, Nova Scotia, for around the same period. While several studies have used information on strandings in the Maritimes to evaluate the status of individual species in Canada (e.g., Nelson and Lien 1996), a comprehensive review of the strandings recorded for Nova Scotia, New Brunswick, and Prince Edward Island has not previously been attempted. Here we report patterns of cetacean strandings in the three Canadian Maritime provinces from 1990 to 2008 inclusive through analysis of spatial and temporal distribution. We also examine the occurrence of types of stranding incidents and the causes of cetacean mortality across suborders and families. Finally, we determine the survival rate of odontocete species after refloating.

Methods

Stranding reports

Reports of strandings of dead or alive cetaceans were assembled initially by the Marine Animal Response Society, the Atlantic Veterinary College, and the New Brunswick Museum. Records of strandings collected by the Grand Manan Whale and Seabird Research Station, mainly of Harbour Porpoises (*Phocoena phocoena*) found dead in fishing weirs around Grand Manan Island, constitute a separate set of regionally focused data that have not been incorporated into this study (GMWSRS 2001). Sampling effort varied across stranding events, depending on the availability of volunteers, the accessibility of sites, the state of funding for each of the organizations, the equipment that was available, and the physical condition of the cetacean upon discovery. At a minimum, cetacean taxon (ideally to species), date, location, and incident type were recorded for each stranding event. Whenever possible, photographs were used to confirm species identification, especially when an experienced marine mammologist could not attend an incident. Incident type was identified as *fishing gear* if the animal was observed offshore entangled or entrapped in fishing gear, as a *live stranding* if the animal was found alive onshore, as a *beaching* if the animal was found dead onshore, as *dead at sea* if the animal was found dead offshore, and as *natural entrapment* if the animal was found trapped in ice. We also use the more general term *stranding* throughout this paper to encompass all of the incident types defined above. If members of a stranding network were present, additional information was collected, including on-site confirmation of species, age category (immature, adult), body measurements, sex, and the results of refloating attempts. Where possible, a complete necropsy by a veterinary pathologist was also completed on dead animals (refer to Geraci and Lounsbury (2005) for sampling methodology).

Temporal distribution and provincial occurrence of strandings and incident types

To determine the spatial distribution of cetacean stranding events over time and the occurrence of incident types, one-way contingency tables with associated Pearson chi-square tests (α = 0.05) were used. For

stranding and spatial distribution, the monthly and yearly frequencies of events for each family and suborder were calculated and compared to their expected frequencies based on a chi-square distribution. The length of shoreline for each province was taken from Natural Resources Canada (2000*), with the different amounts of shoreline per province controlled for by incorporating the relative amount of shoreline (km) of each into the expected values (e.g., [shoreline_{NS}/ shoreline_{Total}]* total species_{A}). Strandings were also mapped and examined visually for areas of concentration. There were no mixed-species stranding events recorded, and all individuals within mass strandings were labeled as the same incident type. Thus, stranding events were used in this analysis rather than stranded individuals, avoiding the likely non-independence of individual data. The natural entrapment incident type was excluded from the analysis due to sparseness of the data.

Linear regressions using least squares were calculated on the square root transformed variables for number of strandings to determine whether the number of incident types for each suborder and family increased or decreased between 1990 and 2008. ANOVAs were used to determine the significance of the regressions. Independence was verified by calculating Durbin-Watson D statistics among residuals, and Lilliefors test was used to test residuals for normality. The residuals were plotted against the predicted values to verify that the assumptions of linearity and homoscedasticity were met. Balaenidae, Monodontidae, Physeteridae, and Ziphiidae were excluded from these analyses, since expected frequencies were too low (< 5) to permit the estimation of useful probabilities (Hill and Lewicki 2006).

Causes of mortality

Partial or full necropsies were performed by a veterinary pathologist on many of the carcasses of stranded animals. Detailed information on 105 animals is included in this study: 56 Harbour Porpoises, 37 Atlantic White-sided Dolphins (*Lagenorhynchus acutus*), and 12 Long-finned Pilot Whales (*Globicephala melas*) [n = 4 (Nova Scotia), 3 (New Brunswick), 98 (Prince Edward Island)]. Depending on the state of preservation of the carcass, gross examination of these animals was complemented by microscopic, bacteriological, and parasitological examination.

Categories of mortality identified included *disease*, *anthropogenic*, *mishap,* and *unknown*. Disease was defined as any condition that was considered sufficient to have killed the animal or to have weakened it such that it might strand. Acute or chronic infection, chronic trauma causing incapacitation leading to gradual starvation and poor nutritional condition, and poor nutritional condition of undetermined cause were included in this category. Anthropogenic causes included evidence of entrapment in fishing gear or collision with boats. Animals were considered to have died from mishap under the following circumstances: they were found alive onshore during or following certain adverse environmental conditions (e.g., strong onshore wind and high tide) and necropsy revealed no evidence of an underlying disease process following death or euthanasia. A few animals found dead ashore were also included in this category if environmental circumstances at the time suggested the preceding as a likely cause. Most animals found dead ashore with no evidence of disease were considered to have died of an unknown cause; advanced postmortem decomposition was partly responsible for some of these unknown causes of death.

One-way contingency tables with associated Pearson chi-square tests (α = 0.05) were used to examine the distribution of causes of mortality (disease or mishap) for each of the three species included in this analysis. Due to the few cases where necropsy identified anthropogenic causes as leading to death, this category was excluded from analysis. Animals for which the cause of mortality was unknown were also excluded. The causes of mortality were compared between species using one-way contingency tables with associated Pearson chi-square tests (α = 0.05). Long-finned Pilot Whales were excluded from this part of the analysis due to the low sample size of these whales that were necropsied.

Short-term survival after refloating

A refloating (live release) event was considered successful when a live stranded animal, after being pushed back into deeper water, was observed to swim away without immediately restranding; the long-term survival of such animals was not observed. In order to determine whether any variables can be used to predict the success of odontocete refloating attempts, a complete logistic regression, with sex and age categories as the independent variables, was applied to the data with 50 iterations. All odontocetes for which refloating was attempted and for which sex and age data were available were included in the analysis (n = 205). Mysticetes were excluded from the analysis, as it is extremely rare that a baleen whale is small enough for refloating to be attempted. The significance of the model was determined through a log-likelihood test. McFadden's rho was used to compare the likelihood for the constant-only model to the likelihood for the model with the predictor (Hill and Lewicki 2006). All analyses were done using the statistical package SYSTAT 12.

Results

Stranding events

There were a total of 640 stranding events recorded for the Maritimes during 1990–2008, involving 19 species and 881 individuals of both sexes and varying age groups (Table 1). The majority of strandings (61%) involved Atlantic White-sided Dolphin (23%), Harbour Porpoise (21%) or Long-finned Pilot Whale

TABLE 1. Species (grouped by family), sex, and age category of cetaceans stranded in Nova Scotia (NS), New Brunswick (NB), and Prince Edward Island (PEI) from 1990 to 2008.

	Stranding events					Individuals (sex)			Individuals (age category)		
Species	Total	NS	NB	PEI	Unknown	Male	Female	Unknown	Adult	Immature	Unknown
Delphinidae											
Lagenorhynchus acutus	204	84	5	115	0	17	45	142	41	10	153
Tursiops truncatus	1	1	0	0	0	0	0	1	0	0	1
Delphinus capensis	3	3	0	0	0	0	0	3	0	0	3
Delphinus delphis	3	2	1	0	0	2	1	0	1	0	2
Stenella coeruleoalba	15	15	0	0	0	6	5	4	0	1	14
Lagenorhynchus albirostris	5	4	0	1	0	3	0	2	1	0	4
Globicephala melas	153	125	3	25	0	20	23	110	17	12	124
Balaenidae											
Eubalaena glacialis	17	7	4	0	6	6	2	9	3	4	10
Balaenopteridae											
Balaenoptera physalus	31	13	5	11	2	5	3	23	5	3	23
Megaptera novaeangliae	32	26	2	0	4	5	2	25	1	3	28
Balaenoptera acutorostrata	58	38	6	13	1	13	6	39	10	8	40
Balaenoptera borealis	8	7	0	1	0	0	1	7	1	0	7
Monodontidae											
Delphinapterus leucas	7	2	5	0	0	1	3	3	2	0	5
Phocoenidae											
Phocoena phocoena	186	54	65	64	3	64	65	57	39	47	100
Physeteridae											
Kogia sima	1	1	0	0	0	0	1	0	0	0	1
Kogia breviceps	6	5	1	0	0	1	2	3	0	1	5
Physeter macrocephalus	49	28	5	16	0	4	21	24	2	9	38
Ziphiidae											
Hyperoodon ampullatus	2	2	0	0	0	1	1	0	0	1	1
Mesoplodon bidens	2	1	1	0	0	2	0	0	0	0	2
Unknown species											
Unidentified mysticete	8	7	0	1	0	0	0	8	0	0	8
Unidentified odontocete	18	18	0	0	0	0	0	18	0	0	18
Unidentified cetacean	72	56	1	4	11	0	1	71	0	0	72
Total	**881**	**499**	**104**	**251**	**27**	**150**	**182**	**549**	**123**	**99**	**659**

(17%). For the most part, stranding events were of single animals (93%). However, 22 events involved 2 animals (3.4%), and 17 events were composed of 3–8 animals (2.7%). Five stranding events involved more than 10 animals (0.8%), 4 of which involved Atlantic White-sided Dolphins (14, 15, 26, and 40 animals). The largest mass stranding was composed of 60 Long-Finned Pilot Whales. There were no mixed-species strandings recorded during the time period considered here.

Temporal distribution of strandings

There was significant variability in the monthly and annual distribution of stranding events when examined by suborder (Table 2). The number of strandings involving odontocetes peaked in 1993 (Figure 1a); stranding of odontocetes occurred most often in late summer, with an increased number of stranding events in August (Figure 2a). Among odontocetes, Harbour Porpoises accounted for the majority of strandings in 1993, and Sperm Whales (*Physeter macrocephalus*) were recorded stranding most often in 2005. Strandings of dolphin species varied considerably between years without any obvious peak year (Figure 1b). Linear regression suggests that there is no consistent trend in odontocete strandings over time (Table 3). However, Harbour Porpoise data were highly skewed, as some years had much higher numbers of reported strandings than others. When examined by month, both Harbour Porpoises and the dolphin species were encountered stranded most often in late summer (Figure 2b). Sperm whales, conversely, were recorded stranding throughout the year, although with a higher number of events in winter (Figure 2b).

TABLE 2. Chi-square values for the number of stranding events in the Maritimes for each suborder.

Contingency table	χ^2	df	P
Mysticete – Month	47.392	11	< 0.001
Mysticete – Year	58.235	18	< 0.001
Odontocete – Month	226.545	11	< 0.001
Odontocete – Year	92.178	18	< 0.001

Strandings involving mysticetes followed a similar pattern, varying significantly over the years and months. There was a peak in 2006 (Figure 1a) and an increase in reported strandings in late summer (Figure 2a). With-

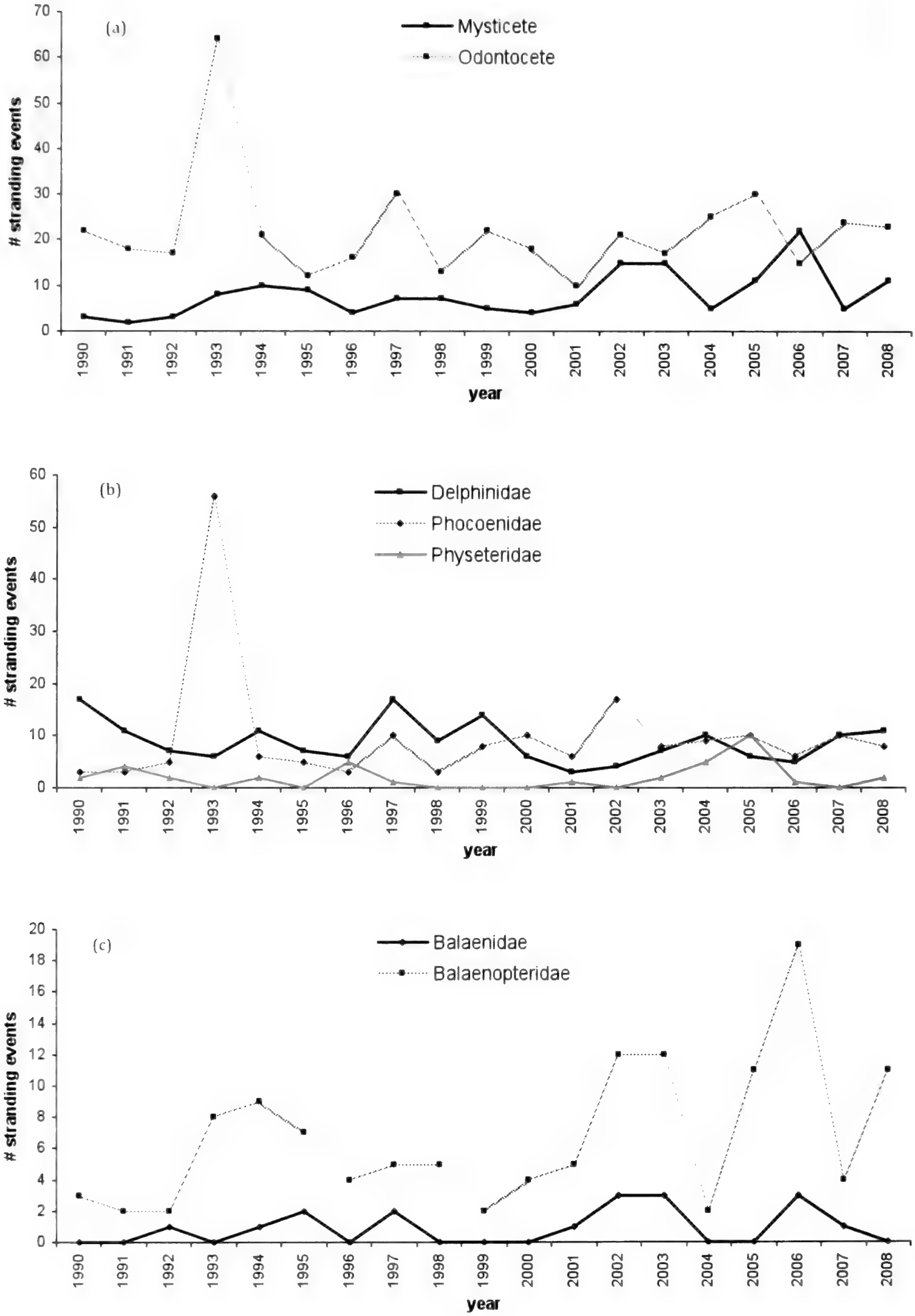


FIGURE 1. The proportion of total stranding events involving (a) mysticetes and odontocetes, (b) delphinids, phocoenids, and physeterids, and (c) balaenids and balaenopterids per year, recorded for the Maritimes, 1990–2008.

TABLE 3. Linear regression results for the number of stranding events in the Maritimes per family and suborder. Variables were square-root (SQR) transformed to meet the assumption of normality when possible. Significant values ($P < 0.05$) are in bold.

Variable	β_0	β_1	r^2	r^2 (adj.)	P	D-Watson	Lilliefors P
SQR (Mysticete)	−165.335	0.084	0.309	0.269	**0.013**	2.025	0.581
SQR (Odontocete)	33.373	−0.014	0.006	< 0.001	0.750	2.266	0.232
SQR (Balaenopteridae)	−144.813	0.074	0.234	0.189	**0.036**	2.108	0.948
SQR (Delphinidae)	68.873	−0.033	0.078	0.023	0.248	1.538	0.377
SQR (Phocoenidae)	−29.315	0.016	0.005	< 0.001	0.774	2.196	<0.001

in the mysticetes, North Atlantic Right Whale (*Eubalaena glacialis*) strandings were recorded most often in 2002–2003 and 2006, while balaenopterid species strandings peaked in 2006 (Figure 1c). When examined by month, both the North Atlantic Right Whale and the balaenopterids were recorded stranding most often in late summer (Figure 2c), the period during which these species are most abundant in waters in the Maritimes. The number of mysticete strandings appears to have increased slightly from 1990 to 2008, although this may in part be due to the relatively high number of strandings observed in 2006 (Table 3, Figure 1a) and perhaps the increasingly organized effort to record strandings in recent years.

Provincial occurrence of strandings

There is also a significant amount of variability in the incidence of stranding events by province within the Maritimes (Figure 3), when examined both by suborder and by family (Table 4). Prince Edward Island had more stranding events than expected by chance alone, even when controlling for the amount of shoreline (Table 5). More strandings off New Brunswick involved Harbour Porpoises than expected, while more balaenopterid and delphinid strandings occurred off Nova Scotia than expected by chance (Table 5). Although Figure 3 does show that stranding events were well distributed along provincial coastlines, there appear to be concentrations of events in the outer Bay of Fundy and in the Halifax region.

Occurrence of incident types

Of the cetaceans stranded across the Maritimes, most were found beached (48%) or live stranded (34%). Entanglement in fishing gear was the primary incident type for 11% of animals, and 5% of whales were found dead at sea. There were also two recorded incidents of ice entrapment, both involving Sperm Whales off Nova Scotia.

TABLE 4. Chi-square test values for the number of stranding events per suborder and family across the Maritime provinces.

Contingency table	χ^2	df	P
Mysticete – Province	15.529	1	< 0.001
Odontocete – Province	142.665	1	< 0.001
Balaenopteridae – Province	18.763	2	< 0.001
Delphinidae – Province	83.068	2	< 0.001
Phocoenidae – Province	131.360	2	< 0.001

The occurrence of the different incident types varied significantly between suborders ($\chi^2 = 15.25$, df = 3, $P = 0.002$) and across families ($\chi^2 = 85.85$, df = 6, $P < 0.001$). Mysticetes were found beached, entangled in fishing gear, or dead at sea more often than expected, but live stranded less frequently than predicted by chance (Table 6). Conversely, odontocetes, more specifically delphinids, were reported stranded alive more often than expected by chance. Harbour Porpoises became entangled in fishing gear and were found dead at sea more often than expected by chance (Table 6).

Causes of mortality

The causes of mortality of the 105 animals for which detailed necropsy information was available are presented in Table 7. Disease appeared to be the main cause of mortality for Harbour Porpoises (Figure 4), affecting this species significantly more often than mishap ($\chi^2 = 13.33$, df = 1, $P < 0.001$). Although mishap appeared to affect more Atlantic White-sided

TABLE 5. Observed and expected frequencies of stranding events for Nova Scotia (NS), New Brunswick (NB), and Prince Edward Island (PEI) from 1990 to 2008, grouped by suborder and family. The expected values reflect the number of stranding events estimated to occur if the events are influenced by chance alone, and are controlled for the amount of shoreline (km) of each province. Instances in which the observed number of stranding events is higher than predicted are in bold.

	NS		NB		PEI	
	Observed	Expected	Observed	Expected	Observed	Expected
Mysticete	**96**	89	17	34	**26**	16
Odontocete	207	266	82	101	**125**	48
Balaenopteridae	**82**	77	13	29	**25**	14
Delphinidae	**110**	107	6	41	**51**	19
Phocoenidae	54	117	**65**	45	**64**	21

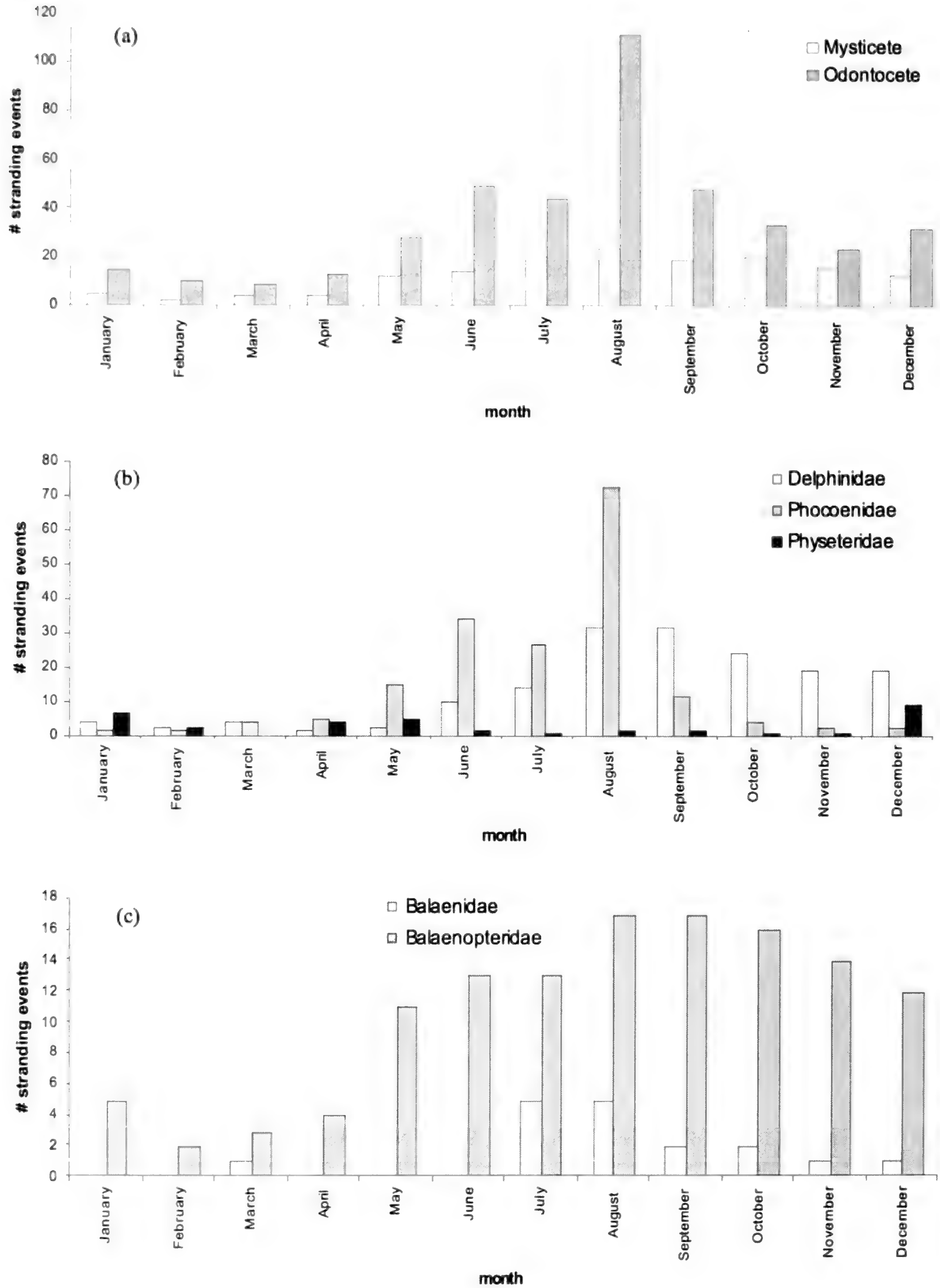


FIGURE 2. The proportion of total stranding events involving (a) mysticetes and odontocetes, (b) delphinids, phocoenids, and physeterids, and (c) balaenids and balaenopterids per month, recorded for the Maritimes, 1990–2008.

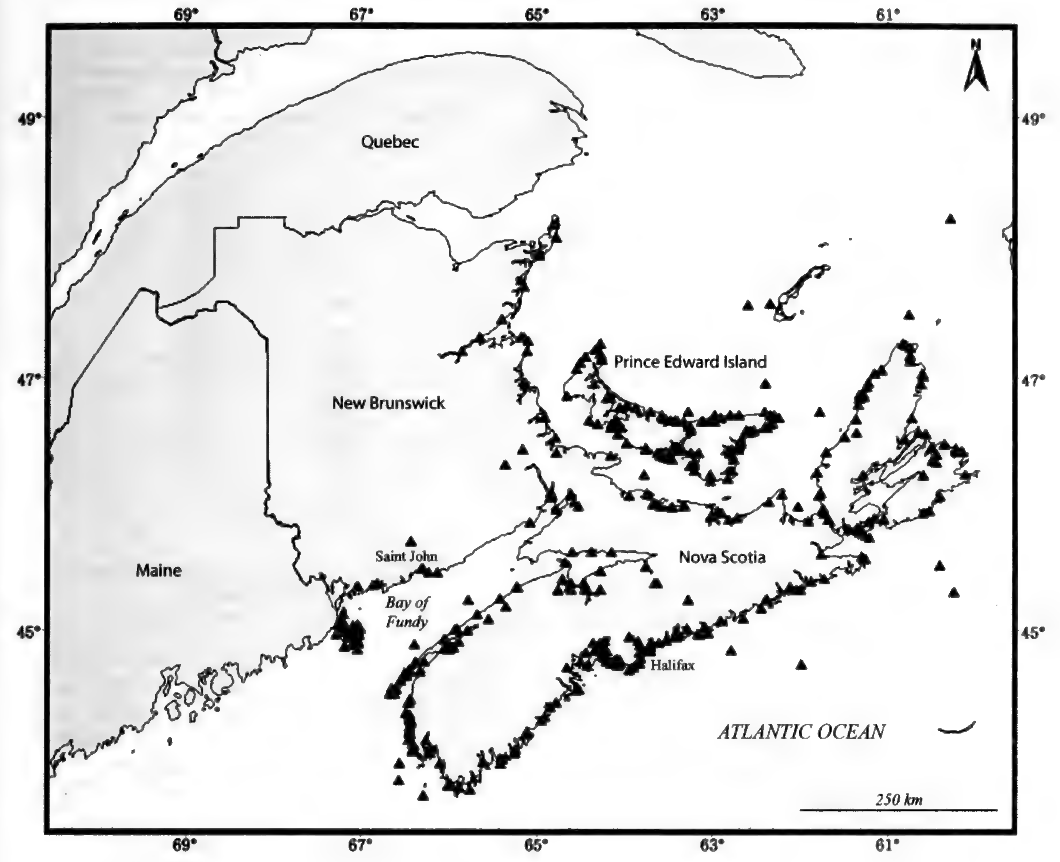


FIGURE 3. Spatial distribution of stranded cetaceans in the Maritimes, 1990–2008 (n = 640). Stranding events that appear to be inland are river incidents.

Dolphins and Long-finned Pilot Whales than did disease (Figure 4), this difference was not significant (χ^2 = 1.64, df = 1, P = 0.201, and χ^2 = 2.00, df = 1, P = 0.157, respectively). However, only a small number of Long-finned Pilot Whales were necropsied, thus providing an incomplete picture of pathology for this species in the region. Stranded Harbour Porpoises showed more evidence of disease than did Atlantic White-sided Dolphins (χ^2 = 8.76, df = 1, P = 0.003), while Atlantic White-sided Dolphins were more likely to die from mishap than Harbour Porpoises (χ^2 = 4.26, df = 1, P = 0.039).

Refloating attempts

Refloating attempts were documented for 205 individuals (23%) over the 19-year period, with an apparent success rate of approximately 83%. The remainder of the animals died, were euthanized, or their fate is unknown. The majority of animals refloated were delphinid species (84%), primarily Atlantic White-sided Dolphins and Long-Finned Pilot Whales. Refloating attempts were also made for 10 Harbour Porpoises, 3 Sperm Whales, a Pygmy Sperm Whale (*Kogia breviceps*), and a Northern Bottlenose Whale (*Hyperoodon ampullatus*), as well as for 4 mysticetes (2 Humpback Whales, *Megaptera novaeangliae*, and 2 Minke Whales, *Balaenoptera acutorostrata*).

Information on both sex and age categories was available for only 23 of the refloated animals (6 females, 17 males; 14 adults, 9 immatures). Once refloated, females appear to have a slightly better survival rate than males (Figure 5a), although the sample size is very small and thus should be interpreted with caution. Age does not appear to play an important role in cetacean survival after refloating, although immature whales do appear to have had a slightly lower death rate than adults (Figure 5b). None of the parameters included in the logistic regression could be attributed to differential success of refloating events (Table 8). Thus, neither the sex nor the age category of a whale

TABLE 6. Observed and expected frequencies of stranding events for each incident type from 1990 to 2008, grouped by sub-order and family. The expected values reflect the number of stranding events estimated to occur if the events are influenced by chance alone. Instances in which the observed number of stranding events is higher than predicted are in bold.

	Beached		Stranded		Anthropogenic		Dead at sea	
	Observed	Expected	Observed	Expected	Observed	Expected	Observed	Expected
Mysticete	**102**	95	11	25	**24**	21	**14**	9
Odontocete	252	259	**83**	69	55	58	21	26
Balaenopteridae	**89**	78	11	22	17	19	**9**	7
Delphinidae	101	102	**57**	29	4	25	4	10
Phocoenidae	103	113	15	32	**50**	27	**15**	11

TABLE 7. Causes of mortality identified in three species of odontocetes. See text for definition of categories.

	Harbour Porpoise	Atlantic White-sided Dolphin	Long-finned Pilot Whale	Total
Disease	25	8[2]	2	35
Anthropogenic cause	5	–	–	5
Mishap	5[1]	14	6	25
Unknown (autolysis)	21 (8)	15 (1)	4	40 (9)
Total	56	37	12	105

[1]Including 4 calves, found between late June and late August, presumably separated from their mother.
[2]Including 3 animals diagnosed with bacteremia/septicemia caused by *Vibrio* sp., possibly secondary to stranding by mishap.

can be used to predict the success of a refloating attempt at this time. However, a larger sample size may reveal patterns that are not evident with the sample size considered here.

Discussion

The majority of cetacean strandings in the Canadian Maritime provinces appear to be single animal events, with significant variability on an annual scale. These data agree with those reported by Hooker et al. (1997), who found that strandings occurred variably throughout Nova Scotia and also varied between years and months. Relatively more strandings occurred in the summer months during our study period. In part, this likely reflects increased reporting effort during the summer, a time when people visit the coastlines most frequently (Hooker et al. 1997; Norman et al. 2004; Evans et al. 2005). However, this pattern may also reflect seasonal movements of small odontocetes that are inshore in the region during the summer months but move to more offshore waters during the winter (e.g., Neave and Wright 1968; Payne and Heinemann 1993). The increase in the number of Sperm Whale strandings reported during the winter months, for instance, may be a consequence of their movement patterns, although these are not yet well resolved (Whitehead 2003). Mass strandings were observed to occur rarely, and were most often composed of Long-finned Pilot Whales or Atlantic White-sided Dolphins. This agrees with previous studies of strandings off Nova Scotia and Newfoundland (Sergeant 1982; Hooker et al. 1997) and may be indicative of the relatively high abundance of those two species within waters in the Maritimes (Hooker et al. 1997; Reeves et al. 2002).

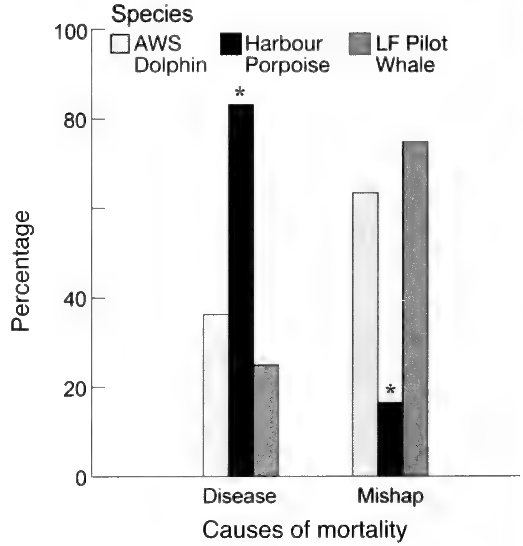


FIGURE 4. The main documented causes of mortality for Atlantic White-sided Dolphins (AWS), Harbour Porpoises (HP), and Long-finned Pilot Whales (LF). Asterisks denote significant differences ($P < 0.001$) between causes of mortality for each species, based on chi-square tests.

While strandings appear to be well distributed along provincial coastlines, there do appear to be slight con-

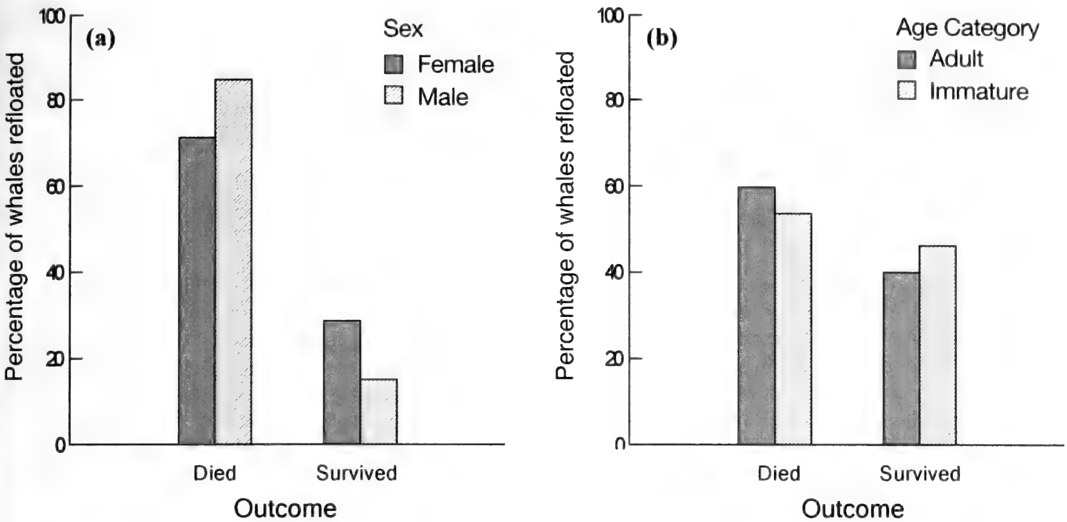


FIGURE 5. Odontocete outcome (died, survived) after refloating attempts: (a) grouped by sex and (b) grouped by age.

centrations of events in the outer Bay of Fundy and in the Halifax region. The Halifax concentration is undoubtedly an artifact of reporting by the Marine Animal Response Society. There is probably some observer bias in the Bay of Fundy as well, with whale researchers concentrated in the outer bay, where whales occur with greatest frequency. Relatively inaccessible coastlines, such as the roadless coastline immediately northeast of Saint John, may contribute to the lack of reported strandings in some areas. The higher number of strandings reported along the coast of Prince Edward Island than expected may be due to high levels of effort, facilitated by the province's small size, accessible shoreline, and locally well-known stranding network at the Atlantic Veterinary College. There may also be a higher proportion of accessible beaches along its coastline, increasing the likelihood that strandings will be noticed by chance observers. Overall, though, it appears that there are as yet not enough data to identify with certainty any areas in the Maritimes that may be particularly prone to live or dead cetacean stranding events.

Incident types

The number of reported mysticete events involving dead animals (beached or dead at sea) was higher than predicted. The greater number of dead mysticetes reported may be a consequence of their relatively higher buoyancy, resistance to dismemberment by scavengers, and greater visibility (Béland et al. 1987), which increases the likelihood that the animals will be seen by passing vessels or will wash ashore and be encountered by human observers. Conversely, odontocetes appeared to strand alive more often than was predicted by chance alone. This may be due, in part, to the propensity for toothed whales to mass strand (Geraci 1978; Sergeant 1982). The mass stranding events (involving more than two animals) recorded in the Maritimes during the period considered here involved only toothed whales, particularly Atlantic White-sided Dolphins and Long-Finned Pilot Whales. Both of these species seem to show a propensity to strand by mishap. During such events, healthy animals within the stranded group may survive longer on shore than animals that strand due to illness or injury, increasing the chance that an observer will record them as stranded alive.

More baleen whales in the Maritimes were observed entangled in fishing gear than predicted by chance alone. This may be a consequence of mysticete foraging strategies, namely bulk foraging by skimming and lunging (Bowen et al. 2002). Such strategies render baleen whales vulnerable to entanglement in longlines, pot trap gear, and other moorings resting near the surface (Northridge 1991; Johnson et al. 2005). Odontocetes, with the exception of Harbour Porpoises, do not appear to become entangled in fishing gear more often than predicted by chance. Incidental catch of Harbour Porpoises, especially in gillnets, was a major cause of concern in the Maritimes during the study period covered here (Trippel et al. 1996). Current efforts are focused on mitigating this negative interaction with local fisheries (e.g., Trippel et al. 1999).

Causes of mortality of necropsied animals

Disease was identified in a larger proportion of stranded Harbour Porpoise than predicted statistically. Atlantic White-sided Dolphins and Long-finned Pilot Whales, conversely, both appeared to have suffered

TABLE 8. Complete logistic regression results for the survival of refloated odontocetes of different ages and sexes. The significance of the model is calculated with a log-likelihood test. A McFadden's rho value between 0.2 and 0.4 indicates significant correlation.

Parameter	Estimate	SE	Z	P	Log-likelihood (df = 2)	Log-likelihood P	McFadden's rho^2
Constant	−0.882	0.746	−1.18	0.237	−12.042	0.272	0.108
Sex	1.537	1.32	1.165	0.244			
Age category	−1.658	1.261	−1.31	0.189			

equally from mishap and disease. There is evidence that the echolocation system of odontocetes typically found offshore or on the continental shelf may be less suitable as a navigational aid in shallow coastal environments than that of inshore or estuarine species, such as Harbour Porpoises (Ketten 1991, 1994; Reeves et al. 2002). Inshore species are more likely to be sick or injured when found stranded, since healthy animals should be adept at navigating in relatively shallow coastal waters. This may have important implications for stranding networks wishing to assist stranded animals. The prospect for successful assistance may be reduced for Harbour Porpoises, which are more likely to be affected by disease or injury when found ashore. Conversely, offshore species such as the Atlantic White-sided Dolphin and Long-finned Pilot Whale appear to be as likely to strand as a result of mishap as of disease.

Limitations of stranding information and management implications

The use of stranding information has inherent limitations (Klinowska 1985). As noted, variation in the number of reported strandings in the Maritimes between provinces and over time may reflect the relative abundance of a species in a region at a given time. Levels of human effort and efficiency in locating and reporting strandings often vary over time and between regions and may also affect the quality of the data. The likelihood that a stranding will be reported is also dependent on physical oceanographic features that bring the body of the animal to shore, such as upwelling and downwelling (Norman et al. 2004). The degree of buoyancy of different species and different body states (healthy or emaciated) and the currents and wind also affect when and where the animal will be found (Norman et al. 2004; Walker et al. 2005). Categories used to describe causes of mortality may often underestimate the effect of human activities on stranding events; while entanglement in fishing gear and ship strikes often result in identifiable external injuries, it is more difficult to link the use of sonar signals in military exercises and seismic surveys to strandings (see Weilgart 2007 for a review; Simmonds and Lopez-Jurado 1991; Engel et al. 2004).

Despite these limitations and the relatively recent efforts to collect cetacean stranding data broadly in the Maritimes, such information has already contributed to knowledge about cetaceans in the waters of the region (e.g., Hooker et al. 1999; Lucas and Hooker 2000; Wimmer 2003). Information on the success rate of refloating attempts can also play a role in the development of rapid and efficient triage strategies, enabling stranding networks to allocate resources most effectively during stranding events (Geraci and Lounsbury 2005). To date, refloating attempts in the Maritimes appear to be largely successful for small odontocetes found alive, but the use of tracking tags on such animals would provide more information on survival and movement patterns after refloating (Geraci and Lounsbury 2005). The continuing collection of such data in the Maritimes may also help in predicting where stranding events are most likely to occur in the future and lead to the development of management strategies. Stranding information on Harbour Porpoise incidental catch has already led to an increased effort to mitigate the effect of fisheries on this species through the development of alternative fishing practices and equipment (e.g., Trippel et al. 1999; Culik et al. 2001).

The provincial stranding networks have only recently developed the central database of stranding event data used in this study. This collaboration should permit more effective information sharing between New Brunswick, Nova Scotia, and Prince Edward Island in the future. It should also play an important role in furthering understanding of both the biology of and the management options for marine mammals in waters of the Maritimes.

Acknowledgments

We thank the many volunteers, fisheries officers from Fisheries and Oceans Canada, Parks Canada wardens, and provincial Natural Resources officers who work closely with stranding networks in the Maritimes and help respond to incidents, collect data and samples, and maintain the databases. Chuck Gallison, Department of Energy, Environment and Forestry, provided information on stranding events on Prince Edward Island. We also thank Hal Whitehead and an anonymous reviewer for comments and useful feedback on the manuscript. This study was supported financially by the Nova Scotia Marine Animal Response Society, the Government of Canada Habitat Stewardship Program for Species at Risk, and the Canadian Cooperative Wildlife Health Centre, Atlantic Veterinary College, University of Prince Edward Island.

Documents Cited (marked * in text)

Natural Resources Canada. 2000. Canada Centre for Remote Sensing. GeoAccess Division. http://atlas.nrcan.gc.ca/site/english/learningresources/facts/coastline.html#c4 [accessed 30 March 2007].

Literature Cited

Balcomb, K.C., and **D. E. Claridge.** 2001. A mass stranding of cetaceans caused by naval sonar in the Bahamas. Bahamas Journal of Science 8: 2-12.

Béland, P., D. Martineau, P. Robichaud, R. Plante, and **R. Greendale.** 1987. Échouages de mammifères marins sur les côtes du Québec dans l'estuaire et le golfe du Saint Laurent de 1982 à 1985. Canadian Technical Report of Fisheries and Aquatic Sciences 1506. 44 pages.

Bouquegneau, J. M., V. Debacker, S. Gobert, and **J. P. Nellissen.** 1997. Toxicological investigations on four sperm whales stranded on the Belgian coast: inorganic contaminants. Biologie 67 (Supplement): 75-78.

Bowen, W. D., A. J. Read, and **J. A. Estes.** 2002. Feeding ecology. Pages 217-246 *in* Marine Mammal Biology: An Evolutionary Approach. *Edited by* A. R. Hoelzel. Blackwell Publishing, Oxford.

Brabyn, M. W. 1991. An analysis of the New Zealand whale stranding record. New Zealand Department of Conservation, Wellington, Science and Research Series 29: 1-47.

Brabyn, M. W., and **I. G. McLean.** 1992. Oceanography and coastal topography of herd-stranding sites for whales in New Zealand. Journal of Mammalogy 73: 469-476.

Cordes, D. O. 1982. The causes of whale strandings. New Zealand Veterinary Journal 30: 21-24.

Culik, B. M., S. Koschinski, N. Tregenza, and **G. M. Ellis.** 2001. Reactions of harbor porpoises *Phocoena phocoena* and herring *Clupea harengus* to acoustic alarms. Marine Ecology Progress Series 211: 255-260.

Dailey, M. D., and **W. A. Walker.** 1978. Parasitism as a factor (?) in single strandings of southern California cetaceans. Journal of Parasitology 64: 593-596.

Dudok van Heel, W. H. 1962. Sound and cetacea. Netherlands Journal of Sea Research 1: 407-507.

Engel, M. H., M. C. C. Marcondes, C. C. A. Martins, F. O Luna, R. P. Lima, and **A. Campos.** 2004. Are seismic surveys responsible for cetacean strandings? An unusual mortality of adult humpback whales in Abrolhos Bank, northeastern coast of Brazil. International Whaling Commission Document SC/56/E28.

Evans, P. G. H., and **P. S. Hammond.** 2004. Monitoring cetaceans in European waters. Mammal Review 34: 131-156.

Evans, K., R. Thresher, R. M. Warneke, C. J. A. Bradshaw, M. Pook, D. Thiele, and **M. A. Hindell.** 2005. Periodic variability in cetacean strandings: links to large-scale climate events. Biology Letters 1: 147-150.

Félix, F., B. Haase, J. W. Davis, D. Chiluiza, and **P. Amador.** 1997. A note on recent strandings and bycatches of sperm whales (*Physeter macrocephalus*) and humpback whales (*Megaptera novaeangliae*) in Ecuador. Report of the International Whaling Commission 47, SC/48/O 14: 917-919.

Fernández, A., J. F. Edwards, F. Rodríguez, A. Espinosa de los Monteros, P. Herráez, P. Castro, J. R. Jaber, V. Martin, and **M. Arbelo.** 2005. "Gas and fat embolic syndrome" involving a mass stranding of beaked whales (family Ziphiidae) exposed to anthropogenic sonar signals. Veterinary Pathology 42: 446-457.

Ferrero, R. C., and **L. M. Tsunoda.** 1989. First record of a bottlenose dolphin (*Tursiops truncatus*) in Washington State. Marine Mammal Science 5: 302-5.

Ferrero, R. C., J. Hodder, and **J. Cesarone.** 1994. Recent strandings of rough-toothed dolphins, *Steno bredanensis*, on the Oregon and Washington coasts. Marine Mammal Science 10: 114-6.

Gearin, P. J., S. R. Melin, R. L. DeLong, H. Kajimura, and **M. A. Johnson.** 1994. Harbor porpoise interactions with a Chinook salmon set-net fishery in Washington State. Report of the International Whaling Commission (special issue) 15: 427-38.

Geraci, J. R. 1978. The enigma of marine mammal strandings. Oceanus 21: 38-47.

Geraci, J. R., and **V. J. Lounsbury.** 2005. Marine mammals ashore: a field guide for strandings. National Aquarium in Baltimore. 372 pages.

Goold, J. C., H. Whitehead, and **R. J. Reid.** 2002. North Atlantic sperm whale, *Physeter macrocephalus*, strandings on the coastlines of the British Isles and eastern Canada. Canadian Field-Naturalist 116: 371–388.

Grand Manan Whale and Seabird Research Station. (GMWSRS). 2001. Guidelines for releasing harbour porpoises and other whales from herring weirs. Grand Manan Whale and Seabird Research Station Bulletin 3. 12 pages.

Hill, T., and **P. Lewicki.** 2006. Statistics: Methods and Applications. StatSoft. 832 pages.

Hooker, S. K., R. W. Baird, and **M. A. Showell.** 1997. Cetacean strandings and bycatches in Nova Scotia, eastern Canada, 1991-1996. International Whaling Commission Document SC/49/05.

Hooker, S. K., H. Whitehead, and **S. Gowans.** 1999. Marine protected area design and the spatial and temporal distribution of cetaceans in a submarine canyon. Conservation Biology 13: 592-602.

Jauniaux, T., L. Brosens, E. Jacquinet, D. Lambrigts, and **F. Coignoul.** 1997. Pathological investigations on sperm whales stranded on the Belgian and Dutch coasts. Biologie 67 (Supplement): 63-67.

Johnson, A., G. Salvador, J. Kenney, J. Robbins, S. Kraus, S. Landry, and **P. Clapham.** 2005. Fishing gear involved in entanglements of right and humpback whales. Marine Mammal Science 21: 635-645.

Joiris, C. R., L. Holsbeek, M. Bossicart, and **G. Tapia.** 1997. Mercury and organochlorines in four sperm whales stranded on the Belgian coast, November 1994. Biologie 67 (Supplement): 69-73.

Kenyon, K. W. 1961. Cuvier beaked whales stranded in the Aleutian Islands. Journal of Mammalogy 42: 71-76.

Ketten, D. R. 1991. The marine mammal ear: specializations for aquatic audition and echolocation. Pages 717-754 *in* The Evolutionary Biology of Hearing. *Edited by D.* Webster, R. Fay, and A. Popper. Springer-Verlag, New York.

Ketten, D. R. 1994. Functional analyses of whale ears: adaptations for underwater hearing. IEEE Proceedings in Underwater Acoustics 1: 264-270.

Klinowska, M. 1985. Interpretation of the UK cetacean stranding records. Report of the International Whaling Commission 35: 459-467.

Lawson, J. W., and **J. D. Eddington.** 1998. A first eastern Canadian stranding record for Risso's Dolphin, *Grampus griseus*. Northeastern Naturalist 5: 215-218.

Le Boeuf, B. J., M. H. Pérez-Cortés, R. J. Urbán, B. R. Mate, and **U. F. Ollervides.** 2000. High gray whale mortality and low recruitment in 1999: potential causes and

implications. Journal of Cetacean Research and Management 2: 85-99.

Lucas, Z. N., and **S. K. Hooker.** 2000. Cetacean strandings on Sable Island, Nova Scotia, 1970-1998. Canadian Field-Naturalist 114: 45-61.

Maldini, D., L. Mazzuca, and **S. Atkinson.** 2005. Odontocete stranding patterns in the main Hawaiian Islands (1937-2002): how do they compare with live animal surveys? Pacific Science 59: 55-67.

McAlpine, D. F. 1985. First records of the Sperm Whale (*Physeter macrocephalus*) from New Brunswick and the Bay of Fundy. Le Naturaliste canadien 112: 433-434.

McAlpine, D. F., and **M. Rae.** 1999. First confirmed reports of Beaked Whales, cf. *Mesoplodon bidens* and *M. densirostris* (Ziphidae) from New Brunswick. Canadian Field-Naturalist 113: 293-295.

McAlpine, D. F., L. D. Murison, and **E. P. Hoberg.** 1997. New records for the Pygmy Sperm Whale, *Kogia breviceps* (Physeteridae) from Atlantic Canada with notes on diet and parasites. Marine Mammal Science 13: 701-704.

McAlpine, D. F., M. C. S. Kingsley, and **P.-Y. Daoust.** 1999. A lactating record-age St. Lawrence Beluga (*Delphinapterus leucas*). Marine Mammal Science 15: 854-859.

Mignucci-Giannoni, A. A., S. Toyos-González, J. Pérez-Padilla, M. A. Rodríguez-López, and **J. Overing.** 1999. Mass stranding of pygmy killer whales (*Feresa attenuata*) in the British Virgin Islands. Journal of the Marine Biological Association of the UK 80: 759-760.

Mitchell, E. D., and **V. M. Kozicki.** 1975. Autumn stranding of a northern bottlenose whale (*Hyperoodon ampullatus*) in the Bay of Fundy, Nova Scotia. Journal of the Fisheries Research Board of Canada 32: 1019-1040.

Neave, D. G., and **B. S. Wright.** 1968. Seasonal migrations of the Harbor Porpoise (*Phocoena phocoena*) and other cetacea in the Bay of Fundy. Journal of Mammalogy 49: 259-264.

Nelson, D., and **J. Lien.** 1996. The status of the long-finned pilot whale, *Globicephala melas*, in Canada. Canadian Field-Naturalist 110: 511-524.

Norman, S. A., M. M. Muto, D. J. Rugh, and **S. E. Moore.** 2000. Gray whale strandings in 1999 and a review of stranding records in 1995-1998. Paper SC/52/AS5 presented to the International Whaling Commission Scientific Committee, June 2000, Adelaide, Australia. 36 pages.

Norman, S. A., C. E. Bowlby, M. S. Brancato, J. Calambokidis, D. Duffield, P. J. Gearin, T. A. Gornall, M. E. Gosho, B. Hanson, J. Hodder, S. J. Jeffries, B. Lagerquist, D. M. Lambourn, B. Mate, B. Norberg, R. W. Osborne, J. A. Rash, S. Riemer, and **J. Scordino.** 2004. Cetacean strandings in Oregon and Washington between 1930 and 2002. Journal of Resource Management 6: 87-99.

Northridge, S. P. 1991. An updated world review of interactions between marine mammals and fisheries. FAO Fisheries Technical Paper (734), Suppl. 1. Food and Agriculture Organization of the United Nations, Rome, Italy. 58 pages.

Osborne, R. W., and **T. W. Ransom.** 1988. Two rare strandings in Washington state. Cetus 8: 24-5.

Parsons, E. C. M., I. Birks, P. G. H. Evans, J. C. D. Gordon, J. H. Shrimpton, and **S. Pooley.** 2000. The possible impacts of military activity on cetaceans in West Scotland. European Research on Cetaceans 14: 185-190.

Payne, P. M., and **D. W. Heinemann.** 1993. The distribution of pilot whales (*Globicephala* spp.) in shelf/shelf-edge and slope waters of the northeastern United States, 1978-1988. Report of the International Whaling Commission. Special Issue 14: 51-68.

Piers, H. 1923. Accidental occurrence of the Pygmy Sperm Whale (*Kogia breviceps*) on the coast of Nova Scotia: an extension of its known range; with remarks on the probability of the former presence in these waters of the true Sperm Whale (*Physeter macrocephalus*). Proceedings of the Nova Scotia Institute of Science 15: 95-114.

Reeves, R. R., B. S. Stewart, P. J. Clapham, and **J. A. Powell.** 2002. National Audubon Society Guide to Marine Mammals of the World. Alfred A. Knopf, New York.

Sergeant, D. E. 1982. Mass strandings of toothed whales (Odontoceti) as a population phenomenon. The Scientific Reports of the Whales Research Institute 34: 1-47.

Simmonds, M. P., and **L. F. Lopez-Jurado.** 1991. Whales and the military. Nature 351: 448.

Sundaram, B., A. C. Poje, R. R. Veit, and **H. Nganguia.** 2006. Acoustical dead zones and the spatial aggregation of whale strandings. Journal of Theoretical Biology 238: 764-770.

Trippel, E. A., J. Y. Wang, M. B. Strong, L. S. Carter, and **J. D. Conway.** 1996. Incidental mortality of harbour porpoise (*Phocoena phocoena*) by the gill-net fishery in the lower Bay of Fundy. Canadian Journal of Fisheries and Aquatic Sciences 53: 1294-1300.

Trippel, E. A., M. B. Strong, J. M. Terhune, and **J. D. Conway.** 1999. Mitigation of harbour popoise (*Phocoena phocoena*) by-catch in the gillnet fishery in the lower Bay of Fundy. Canadian Journal of Fisheries and Aquatic Sciences 56: 113-123.

Vanselow, K. H., and **K. Ricklefs.** 2005. Are solar activity and sperm whale *Physeter macrocephalus* strandings around the North Sea related? Journal of Sea Research 53: 319-327.

Walker, R. J., R. O. Keith, A. E. Yankovsky, and **D. K. Odell.** 2005. Environmental correlates of cetacean mass stranding sites in Florida. Marine Mammal Science 21: 327-335

Walsh, M. T., D. Beusse, W. G. Young, J. D. Lynch, E. D. Asper, and **D. K. Odell.** 1991. Medical findings in a mass stranding of pilot whales (*Globicephala macrorhynchus*) in Florida. Pages 75-83 *in* Marine Mammal Strandings in the United States. Proceedings of the Second Marine Mammal Stranding Workshop, Miami, Florida, December 3-5, 1987. *Edited by* John E. Reynolds, III, and Daniel K. Odell. NOAA Technical Report NMFS 98.

Weilgart, L. S. 2007. A brief review of known effects of noise on marine mammals. International Journal of Comparative Psychology 20: 159-168.

Whitehead, H. 2003. Sperm Whales: Social Evolution in the Ocean. University of Chicago Press, Chicago and London. 431 pages.

Wimmer, T. 2003. Distribution of cetaceans on the continental shelf break off Nova Scotia and in adjacent waters with a focus on northern bottlenose whales (*Hyperoodon ampullatus*). Master's thesis, Dalhousie University, Halifax, Nova Scotia, Canada.

Wright, A. J. 2005. Lunar cycles and sperm whales (*Physeter macrocephalus*) strandings on the North Atlantic coastlines of the British Islas and eastern Canada. Marine Mammal Science 21: 145-140.

Received 3 August 2009
Accepted 28 May 2010

Recent Range Expansion of Ruffed Grouse, *Bonasa umbellus*, in Labrador

TONY E. CHUBBS[1, 2] and FRANK R. PHILLIPS[3]

[1]Department of Environment and Conservation, Wildlife Division, Government of Newfoundland and Labrador, Box 3014, Station B, Happy Valley-Goose Bay, Newfoundland and Labrador A0P 1E0 Canada
[2]Department of National Defence, 5 Wing Goose Bay, Box 7002, Station A, Happy Valley-Goose Bay, Newfoundland and Labrador A0P 1S0 Canada; e-mail: techubbs@cablelab.net
[3]Department of Natural Resources, Government of Newfoundland and Labrador, Box 3014, Station B, Happy Valley-Goose Bay, Newfoundland and Labrador A0P 1E0 Canada

Chubbs, Tony E., and Frank R. Phillips. 2010. Recent range expansion of Ruffed Grouse, *Bonasa umbellus*, in Labrador. Canadian Field-Naturalist 124(1): 45–48.

The recent distribution of Ruffed Grouse, *Bonasa umbellus*, has not been documented in Labrador. Here we provide new records, extending northward the known contiguous distribution by 100 to 150 km, and identify three new, possibly discrete, populations.

Key Words: Ruffed Grouse, *Bonasa umbellus*, distribution, range expansion, Labrador.

Four species of the subfamily Tetraoninae (Class Aves) occur in Labrador: two migratory species (Willow Ptarmigan, *Lagopus lagopus*, and Rock Ptarmigan, *L. mutus*) and two non-migratory species (Spruce Grouse, *Falcipennis canadensis*, and Ruffed Grouse, *Bonasa umbellus*). Willow Ptarmigan generally breed on barrens of arctic and subarctic regions of Labrador, while Rock Ptarmigan breed along the north coast and inland at high elevations on some non-forested mountain ranges. Spruce Grouse are cyclically numerous throughout forested regions of Labrador.

Ruffed Grouse are widely distributed throughout deciduous and mixed forests of North America (Johnsgard 1983; Rusch et al. 2000). In eastern Canada, they are commonly associated with hardwood and mixed forests. Most research in Canada on the habitat requirements of Ruffed Grouse and on Ruffed Grouse populations has taken place around the Great Lakes in Trembling Aspen (*Populus tremuloides*) forests (McDonald et al. 1998; Rusch et al. 2000) west to Alberta (Keith 1963).

The distribution of Ruffed Grouse in Labrador has been poorly documented (Ouellet 1990), probably due to sparse human population, low numbers of birds, and limited suitable habitat in the region. The early literature contains little information on the distribution of Ruffed Grouse (Harper 1958; Todd 1963; Ouellet 1990). Most range maps depict the distribution inaccurately and show a contiguous range based on outdated records (Godfrey 1986; Rusch et al. 2000).

Todd (1963) documented Ruffed Grouse in only two regions of Labrador, along the Churchill River near Hamilton Inlet and near Cartwright on the coast of Labrador. However, a more recent study revealed a new subspecies of Ruffed Grouse (*B. u. labradorensis*), described as inhabiting southern Labrador and adjacent regions of Quebec (Ouellet 1990), most often associated with deciduous stands of poplar (*Populus* sp.), alders (*Alnus* sp.), and willows (*Salix* sp.) and small second-growth vegetation along rivers, islands, eskers, and roads (Ouellet 1990). Ouellet (1990) described the range as "the southeastern part of the Québec-Labrador Peninsula from approximately the Churchill River valley to Lake Melville, along the southern Labrador coast, the Strait of Belle Isle and the north shore of the Gulf of St. Lawrence west possibly to Havre Saint-Pierre, Québec." Here we present new sightings extending the known contiguous distribution across Labrador and identify two apparently isolated populations.

Methods

We compiled information on Ruffed Grouse sightings from conservation officers, hunters and trappers, avid birdwatchers, harvest records, and personal observations. We interviewed numerous residents throughout Labrador to determine the presence of the species and collected samples to confirm the presence of Ruffed Grouse, where possible. We combined historical records with our recent information to delineate the current range of the Ruffed Grouse in Labrador (Figure 1).

Results

Western Labrador

Ruffed Grouse have been observed at several locations near Labrador City and appear to have arrived in this area within the last 10 years. Males were observed drumming in spring at a site within the town limits in 2003 (G. Parsons, personal communication; Table 1). Females with broods were recorded along Smokey Mountain Road near Labrador City in the summer of 2005 and 2006 (Table 1). Observations were also made

TABLE 1. Harvest records and sightings of Ruffed Grouse in Labrador and adjacent areas from 1970 to the present.

Labrador Region	Coordinates	*n*, sex	Date	Source
Central				
1. Cache River	53°12.03'N, 61°12.96'W	1 unknown	1990s	J. Thomas
2. Popes Hill	53°02.00'N, 61°20.00'W	1 male	October 1995	T. Chubbs
3. Winokapau Lake	53°13.00'N, 63°15.00'W	1 unknown	1 April 2006	T. Chubbs
4. Double Mer River	54°02.00'N, 59°35.00'W	Several	1980s	B. Michelin
5. Seal Islands, Naskaupi River	54°05.25'N, 61°20.15'W	Several	1970s	L. Montague
6. Sandy Point	53°26.00'N, 60°02.00'W	1 male, 1 unknown	February 1997	T. Chubbs
7. Churchill Falls tailrace road	53°31.00'N, 63°58.00'W	2 unknown	20 May 2000	F. Phillips
8. Little Mecatina River	51°45.99'N, 60°07.65'W	1 unknown	9 July 2001	K. Hogan/C. Wilkerson
Coastal				
9. Port Hope Simpson	52°31.57'N, 56°30.34'W	1 male	October 1997	W. Smith
10. Charlottetown	52°44.49'N, 56°15.82'W	1 unknown	Fall 1999	D. Parr, J. Pretty
11. Postville	54°45.00'N, 60°15.00'W	Several	1980s	W. Lane, G. Gear
Western				
12. Oreway railway siding	52°34.00'N, 65°52.00'W	1 unknown	Late 1980s	K. Krats
13. Smokey Mountain Road	52°57.61'N, 66°55.31'W	2 females, 2 broods	2005, 2006	G. Parsons

along Cemetery Road in Labrador City in 2006. Sightings have been reported annually since 2003 (G. Parsons, personal communication).

Central Labrador

Several Ruffed Grouse sightings were recorded in the early 1990s just west of the Cache River, in central Labrador (J. Thomas, personal communication). In October 1995, a male Ruffed Grouse was harvested by TEC adjacent to the Trans Labrador Highway near the bottom of Popes Hill, approximately 90 km east of Goose Bay, Labrador (Table 1). On 20 May 2000, two individuals of unknown sex were observed on the tailrace road at Churchill Falls by FRP. This area is composed of regenerating White Birch (*Betula papyrifera*), Balsam Poplar, and willows, providing good habitat for Ruffed Grouse. A recent winter sighting along Winakapau Lake suggests the distribution between Happy Valley-Goose Bay and Churchill Falls may be contiguous adjacent to the Churchill River valley.

In the upper Lake Melville area, Ruffed Grouse have been harvested at the outflow of the Double Mer River, Sandy Point, and the lower Naskaupi River by several hunters since at least the 1970s (Table 1). A recent sighting on 9 July 2001 confirmed the presence of Ruffed Grouse on the Little Mecatina River just south of the Quebec-Labrador boundary.

Coastal Labrador

In October 1997, a male Ruffed Grouse was shot near Port Hope Simpson by a hunter (W. Smith) from Mary's Harbour. The specimen had grey phase plumage and was the first specimen recorded from the Port Hope Simpson area. It was collected and deposited in the Newfoundland Museum (catalogue number NFM ORN 195). Another bird was taken by a separate hunter in the same area in the fall of 1997. The location of these records is 110 km southeast of the Cartwright (Sandwich Bay) sighting reported in Todd (1963) and 136 km north of the specimen obtained at Bonne-Espérance, Québec, reported in Ouellet (1990). In recent years, hunters have reported taking several Ruffed Grouse along the Port Hope Simpson forest access road, indicating that the birds are likely now established in the area (D. Parr, personal communication).

In the fall of 1999, a single Ruffed Grouse was observed with a flock of five or six Spruce Grouse while the new forest access road for Charlottetown was being surveyed (Table 1). The observer (D. Parr) retrieved two feathers from the bird that confirmed it as a Ruffed Grouse.

We documented several records of Ruffed Grouse from the Postville area since the 1980s from both hunters and conservation officers (W. Lane and G. Gear, personal communication). Both individuals had previously observed Ruffed Grouse in the upper Lake Melville region, where they are relatively common.

Discussion

The first occurrences of Ruffed Grouse in the Sandwich Bay (Cartwright) and Lake Melville regions were recorded by Turner in 1885 and Low in 1896 (cited in Todd 1963). This distribution apparently remained unchanged through the late 1970s and early 1980s (Ouellet 1990). Ouellet (1990) suggested that the origin of Ruffed Grouse in Labrador goes back to one of the post-glacial periods of climate warming. When climatic conditions deteriorated, with ensuing changes in forest vegetation, he suggested that Ruffed Grouse were no longer capable of moving freely in all directions and eventually became isolated in the suitable habitats that they were occupying.

We suspect that our new records of Ruffed Grouse in Labrador constitute evidence of range expansion by the species rather than range extensions resulting from previously undocumented occurrences (*sensu* Frey 2009). In recent decades, the development of roads,

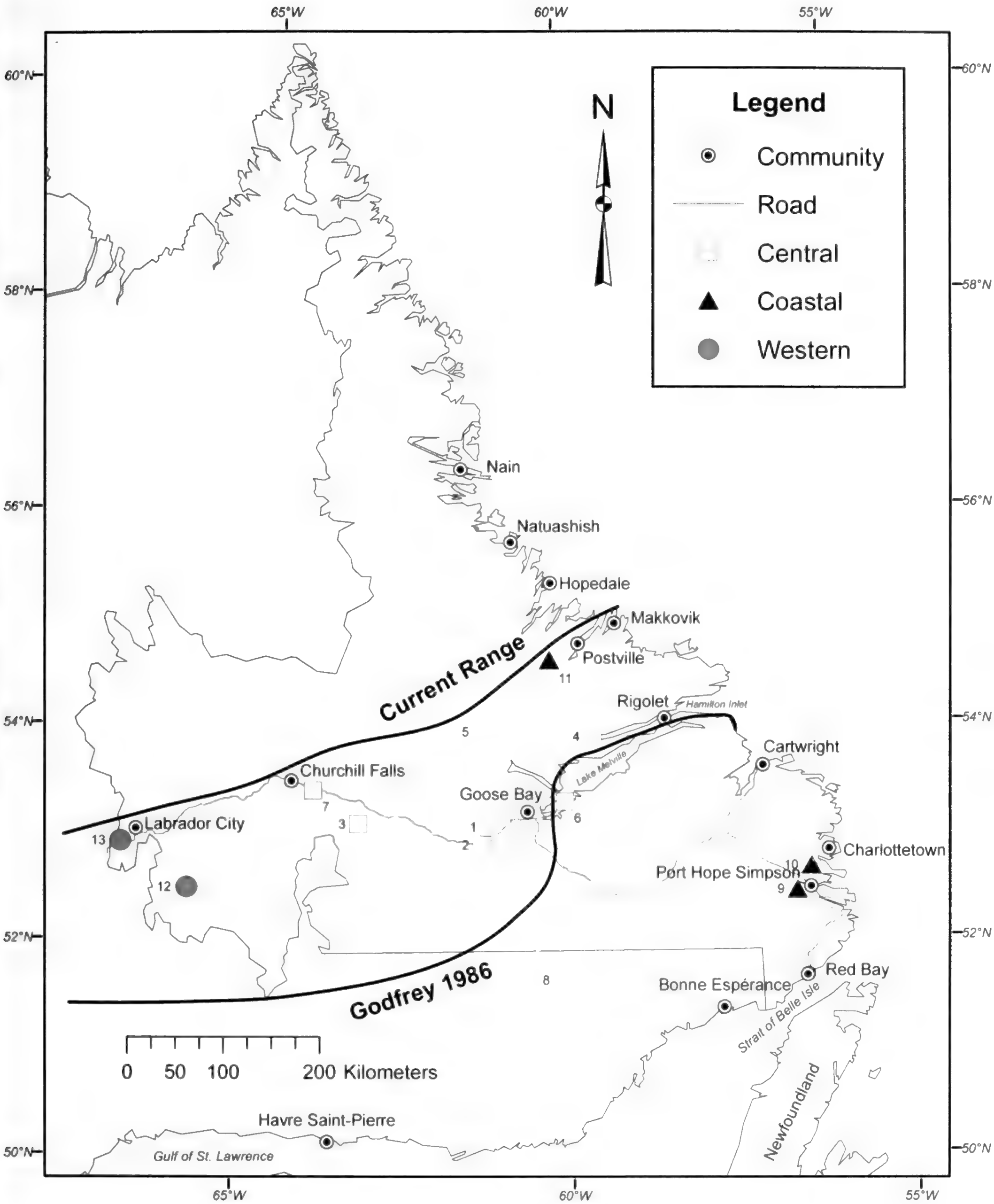


FIGURE 1. Current distribution and recent sightings of Ruffed Grouse in Labrador, and the northern most distribution described by Godfrey (1986). Roman numerals indicate the harvest and sighting locations from Table 1.

railways, expanding forest harvesting operations (Chubbs and Schaefer 1997), and perhaps climate change (Chaulk et al. 2009*) have again changed the forest composition in Labrador, increasing the amount of deciduous forests in some areas and undoubtedly resulting in an increase in habitat favourable to the Ruffed Grouse and a subsequent recent expansion in their range. Our records indicate that Ruffed Grouse have expanded their range since the early 1980s as described by Ouellet (1990) and Todd (1963) and are now established in Labrador West and at two new coastal locations at Postville and Port Hope Simpson.

It is unlikely that these three new populations went undetected, as all our informants were long-term residents of their communities familiar with the fauna of the regions.

The recent occurrence of Ruffed Grouse in Labrador West is likely the result of an increase in deciduous edge habitat created by human-caused forest alterations through mining and road building activities, forestry, and succession following forest fire. We suspect that the Labrador West population of Ruffed Grouse may have expanded north along roads, railways and southern flowing watercourses from eastern Québec, where the species is prevalent (Rusch et al. 2000). Recent forest harvesting operations in the Postville and Port Hope Simpson have probably created enough suitable habitat in the form of deciduous regeneration to support small populations of Ruffed Grouse. Suitable habitat also occurs near Snegamook (54°33'N, 61°30'W) and Shipiskan (54°37'N, 62°15'W) lakes, and we suspect that Ruffed Grouse may exist there as well. These areas are connected by riparian deciduous forests typical of those adjacent areas where populations have been confirmed (this study).

Acknowledgments

Thanks are extended to Gord Parsons for providing details of recent sightings in western Labrador and records from the late Karl Krats. Conservation Officer Dennis Parr collected the Port Hope Simpson specimen from hunter Wayne Smith from Mary's Harbour and confirmed the Charlottetown record. Tom Jung provided the Little Mecatina record observed by biologists Kathy Hogan and Corrine Wilkerson and commented on an earlier draft of the manuscript. Other observations were provided by hunters George Gear, Wilfred Lane, Bernard Michelin, and Wayne Smith; John Thomas, Forester; and Conservation Officers Louis Montague and John Pretty. Thanks to Leanne Elson for earlier drafts of the figure and thanks to David Elliott for the final figure. Comments provided by Paul Linegar and Bruce MacTavish greatly improved the manuscript. We thank reviewer Keith Chaulk for comments that improved the manuscript. Funding for this manuscript was provided through the Newfoundland and Labrador Department of Environment and Conservation, Wildlife Division.

Documents Cited (marked * in text)

Chaulk K. G., T. E. Chubbs, J. D. Jacobs, and **F. Phillips.** 2009. Animal range and climate shifts in Labrador, Canada: 1942-2008. Unpublished manuscript.

Literature Cited

Chubbs, T. E., and **J. A. Schaefer.** 1997. Population growth of Moose, *Alces alces* in Labrador. Canadian Field-Naturalist 111: 238-242.

Frey, J. K. 2009. Distinguishing range expansions from previously undocumented populations using background data from museum records. Diversity and Distributions 15: 183-189.

Godfrey, W. E. 1986. The Birds of Canada. Revised edition. National Museum of Natural Sciences, Ottawa, Ontario. 595 pages.

Harper, F. 1958. Birds of the Ungava Peninsula. University of Kansas Museum of Natural History, Miscellaneous Publication Number 17. 171 pages.

Johnsgard, P. A. 1983.The Grouse of the World. University of Nebraska Press, Lincoln. 413 pages.

Keith, L. B. 1963. Wildlife's ten-year cycle. University of Wisconsin Press, Madison, Wisconsin.

McDonald, J. E., G. L. Storm, and **W. L. Palmer.** 1998. Home range and habitat use of male Ruffed Grouse in managed mixed oak and aspen forests. Forest Ecology and Management 109: 271-278.

Ouellet, H. 1990. A New Ruffed Grouse, Aves: Phasianidae: *Bonasa umbellus*, from Labrador, Canada. Canadian Field-Naturalist 104: 445-449.

Rusch, D. H., S. Destefano, M. C. Reynolds, and **D. Lauten.** 2000. Ruffed Grouse, *Bonasa umbellus*. *In* The Birds of North America number 515. *Edited by* A. Poole and F. Gill. The Birds of North America, Inc., Philadelphia, Pennsylvania.

Todd, W. E. C. 1963. The birds of the Labrador Peninsula and adjacent areas. University Toronto Press, Toronto, Ontario, Canada.

Received 24 February 2009
Accepted 4 June 2010

Colonial Waterbirds Nesting on Egg Island, Lake Athabasca, 2009

Craig Hebert[1], Wayne Nordstrom[2], and Laird Shutt[1]

[1]Environment Canada, Wildlife and Landscape Science Directorate, National Wildlife Research Centre, 1125 Colonel By Drive, Ottawa, Ontario K1A 0H3 Canada
[2]Alberta Parks, Parks Ecology Program, 3rd floor, Oxbridge Place, 9820 – 106 Street, Edmonton, Alberta T5K 2J6 Canada

Hebert, Craig, Wayne Nordstrom, and Laird Shutt. 2010. Colonial waterbirds nesting on Egg Island, Lake Athabasca, 2009. Canadian Field-Naturalist 124(1): 49–53.

In June 2009 a census was conducted of colonial waterbirds breeding on Egg Island in western Lake Athabasca. This island supports the largest breeding colony of Caspian Terns (*Hydroprogne caspia*) in Alberta. California Gulls (*Larus californicus*) and Herring Gulls (*Larus argentatus*) also nest on the island. One hundred and one Caspian Tern nests (=pairs) were counted during 2009. Since 1990, the number of terns nesting on the island appears stable. However, more frequent surveys of waterbird populations are recommended, particularly in light of growing industrial activity in this region.

Key Words: Caspian Tern, *Hydroprogne caspia*, California Gull, *Larus californicus,* Herring Gull, *Larus argentatus*, Egg Island, Lake Athabasca, Alberta.

Egg Island (58.981°N, -110.439°W) in western Lake Athabasca (Figure 1) supports the largest Caspian Tern (*Hydroprogne caspia*) colony in the province of Alberta (http://tpr.alberta.ca/parks/managing/sitedesc_canshield.asp). In recognition of this fact, the island was designated an ecological reserve by the province in 1992. It is the smallest (0.36 ha) such reserve in Alberta. Egg Island is approximately 70 m long by 40 m wide, is elliptical in shape, and has a surface of pebble, cobble, and boulder gravel. It rises to a maximum elevation of approximately 2.5 m above lake level. The island also supports breeding populations of California Gulls (*Larus californicus*) and Herring Gulls (*Larus argentatus*). Terns have likely nested in this area since at least the early 1900s. Sightings of Caspian Terns in the vicinity of Egg Island date back to 1903. Caspian Terns were observed in the Lake Athabasca Delta in June 1903 (Preble 1908) and 1907 (Seton 1911). Soper (1942) made additional sightings in the Delta in late May and late June in 1932 and 1933, respectively. The earliest census of Caspian Terns nesting on Egg Island was completed in 1952 with approximately 20 breeding pairs reported (Salt and Wilk 1958, 1966; Salt and Salt 1976). Surveys were conducted intermittently in subsequent years. In early July 1971, Hohn (1973) visited Egg Island and estimated there were approximately 20 pairs of Caspian Terns and 50-80 pairs of California Gulls nesting on the island. Weseloh and Cocks (1979) censused the island again in June, 1977 and counted 47 Caspian Tern nests along with one Herring Gull nest. They estimated a maximum of 100 pairs of California Gulls nesting on the island. Weseloh and Cocks (1979) provide an excellent summary of the early Caspian Tern accounts for this region. In more recent years, Nordstrom and coworkers visited the island on two occasions. On 12 July 1990, Nordstrom (unpublished data) estimated approximately 150-200 adult Caspian Terns were breeding on the island. Data for other species were not collected. On 11 June 2001, Nordstrom, Vujnovic and Thomas (unpublished data) reported at least 150 pairs of nesting Caspian Terns. They also estimated that there were about 400 adult California Gulls, about 10 adult Herring Gulls, about 60 adult Ring-billed Gulls and about 30 adult Common Terns on/around the island. However, there are no records of the latter two species nesting on the island.

Parts of northern Alberta have seen a significant increase in industrial activity over the past two decades. This is evident in the Fort McMurray area where the Oil Sands are under development (National Energy Board 2004*, Alberta Environment 2008*). A major river, the Athabasca River, flows through Fort McMurray and the area where many of the Oil Sands operations are underway. The river flows northwards into western Lake Athabasca approximately 200 km downstream from Fort McMurray, the industrial hub of Oil Sands development (see Figure 1). The intention of our research was to provide updated information regarding the size of the populations of colonial waterbirds that breed on Egg Island. These data will be used to assess future trends in waterbird populations as a result of environmental change.

Methods

On 14 June 2009, we visited Egg Island via floatplane (Figure 2). Snow and ice drifts were still present in waters adjacent to some parts of the island but, overall, the waters of Lake Athabasca were ice-free. We arrived on the island at 08:00 (Mountain Standard Time, UTC-7) and spent approximately 1 hour counting nests, taking egg measurements for California Gulls, and collecting Caspian Tern and California Gull eggs for toxicological and dietary analysis. Here, we report population, clutch size distribution, and egg size data. Egg volume was estimated using the equation:

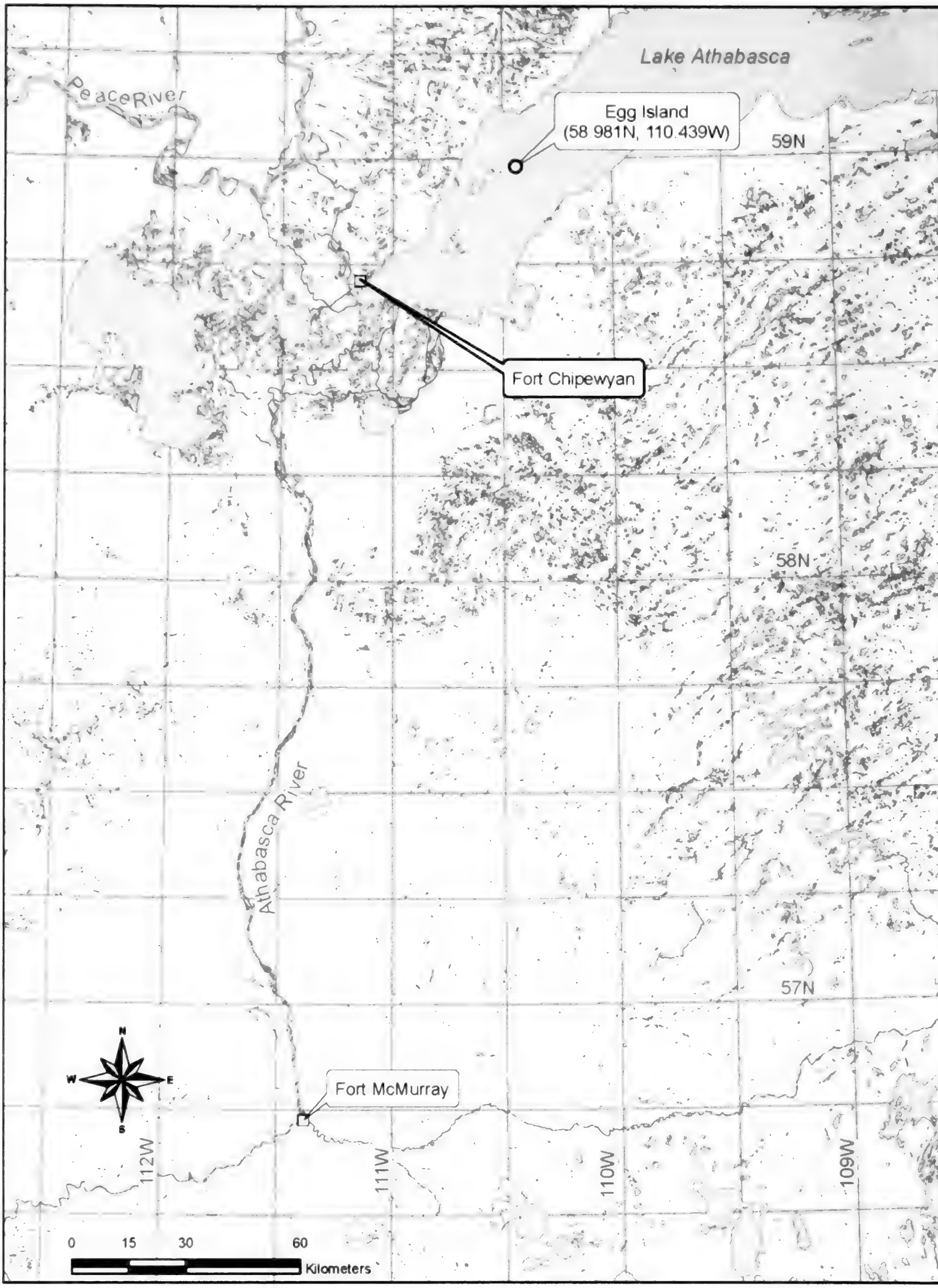


FIGURE 1. Map of the study region.

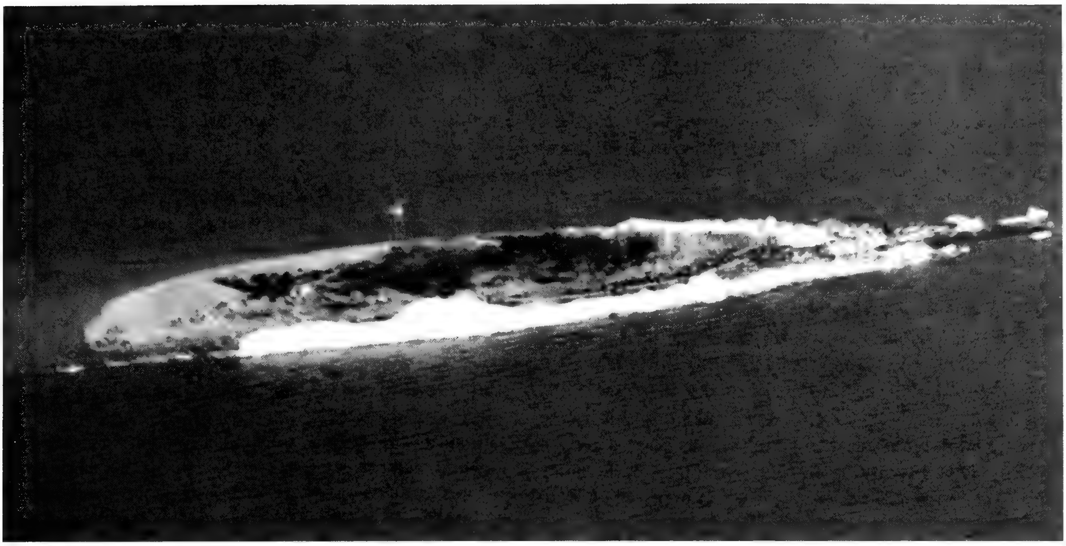


FIGURE 2. Aerial view of Egg Island, Lake Athabasca, 14 June 2009.

$$\text{Volume (cm}^3) = 0.489\ (\text{length} \times \text{breadth}^2)/1000$$
(Ryder 1975)

Two biologists surveyed the entire island and counted nests for each of three species: Caspian Terns, California Gulls, and Herring Gulls. For California Gulls, egg measurements (length and breadth) were obtained from completed 3-egg clutches. Similar data are not reported for the other two species because there were no 3-egg clutches for Caspian Terns and there were few Herring Gull nests.

Results

Caspian Terns were the most abundant species breeding on the island with 101 nests counted (Figure 3). In addition, there were 87 California Gull nests and 3 Herring Gull nests. Clutch size distribution data were also collected and are shown in Table 1. Average clutch size for Caspian Terns breeding in northern North America is three eggs (Bent 1921). Similarly, modal

TABLE 1. Clutch size distribution data for waterbird species nesting on Egg Island, 14 June, 2009.

Species	Clutch Size				Total
	0	1	2	3	
Caspian Tern	29	31	41	0	101
California Gull	14	29	22	22	87
Herring Gull	0	0	1	2	3

FIGURE 3. Approximately one-third of the Caspian Terns breeding on Egg Island, Lake Athabasca, 14 June 2009.

clutch size for California Gulls nesting at another Alberta colony was three eggs (Vermeer 1970). Herring Gulls have also been reported to have a modal clutch size of three eggs (Tinbergen 1960). Clutch size distribution data indicated that egg-laying was still occurring for all species with the gulls somewhat more advanced than the terns. Mean (± standard deviation) egg size data from 3-egg clutches of California Gulls were as follows: length 64.59 ± 2.33 mm, breadth 45.73 ± 1.33 mm, volume 66.14 ± 4.99 cm^3. Mean clutch volume was 198.43 ± 11.00 cm^3. Mean percent difference between the largest and smallest egg within a clutch (intra-clutch variation in egg size) was 9.76 ± 6.20%. With respect to the collection of fresh eggs, the timing of the visit on 14 June was nearly optimal as eggs from all species were available but there were no complete three-egg clutches for Caspian Terns. Future visits (assuming similar weather conditions) could be delayed for several days to ensure the presence of complete clutches for all species.

Discussion

The nest count data reported here are consistent with census information from 1990 and 2001. Although the level of accuracy of the counts varied during the last three surveys, they indicated that the number of Caspian Terns breeding on the island reached its peak during the past two decades and has been stable at 100-200 pairs. This trend combined with forthcoming information regarding contaminant levels in the 2009 eggs will provide a benchmark against which to evaluate future change. In light of growing economic development in this region, more frequent censuses of waterbird populations on Egg Island are recommended. Waterbirds, such as terns and gulls, are useful indicators of environmental quality and ecosystem change (Kushlan 1993; Hebert et al. 1999, 2008). Egg size data for California Gulls were similar to those reported previously for that species in Alberta (Vermeer 1969). However, mean clutch volumes and intra-clutch differences in egg size showed substantial variation among clutches. Such endpoints can be valuable in assessing food stress and their long-term monitoring can provide insights into how ecosystem change may alter food availability for top predators (Hebert et al. 2002, 2009). Regular monitoring of waterbird populations would be a useful addition to programs assessing the potential environmental impacts of Oil Sands development (e.g., Regional Aquatics Monitoring Program, see Golder Associates 2003*) and for assessing ecological change in general.

Acknowledgments

The authors thank Fish and Wildlife Division of Alberta Sustainable Resource Development and Alberta Tourism, Parks, and Recreation for granting permits allowing this work to take place. Permits were also obtained from the Canadian Wildlife Service. Seth Melmock of McMurray Aviation provided transportation to the island. Jeannine Paquette produced Figure 1. A. J. Erskine and C. Stuart Houston provided comments that improved the manuscript. Environment Canada's Ecotoxicology and Wildlife Health Program supported this research.

Documents Cited (marked * in text)

Alberta Environment. 2008. Alberta's Oil Sands: Opportunity, Balance. http://www.environment.alberta.ca/documents/Oil_Sands_Opportunity_Balance.pdf Government of Alberta, Edmonton, Alberta.

Golder Associates. 2003. Oil Sands Regional Aquatics Monitoring Program (RAMP) five-year report. May 2003. http://www.ramp-alberta.org/UserFiles/File/Supporting/RAMP%20Five%20Year%20Report.pdf. Prepared for the RAMP Steering Committee. Calgary, Alberta.

National Energy Board. 2004. Canada's Oil Sands: Opportunities and Challenges to 2015. http://www.neb.gc.ca/clf-nsi/rnrgynfmtn/nrgyrprt/lsnd/lsnd-eng.html. Government of Canada, National Energy Board, Calgary, Alberta.

Literature Cited

Bent, A. C. 1921. Life histories of North American gulls and terns. U.S. National Museum Bulletin 113.

Hebert, C. E., R. J. Norstrom, and **D. V. Weseloh.** 1999. A quarter century of environmental surveillance: the Canadian Wildlife Service's Great Lakes Herring Gull Monitoring Program. Environmental Reviews 7: 147-166.

Hebert, C. E., J. L. Shutt, and **R. O. Ball.** 2002. Plasma amino acid concentrations as an indicator of protein availability to breeding Herring Gulls (*Larus argentatus*). Auk 119: 185-200.

Hebert, C. E., D. V. C. Weseloh, A. Idrissi, M. T. Arts, R. O'Gorman, O. T. Gorman, B. Locke, C. P. Madenjian, and **E. F. Roseman.** 2008. Restoring piscivorous fish populations in the Laurentian Great Lakes causes seabird dietary change. Ecology 89: 891-897.

Hebert, C. E., D. V. C. Weseloh, A. Idrissi, M. T. Arts, and **E. F. Roseman.** 2009. Diets of aquatic birds reflect changes in the Lake Huron ecosystem. Aquatic Ecosystem Health and Management 12: 37-44.

Hohn, E. O. 1973. The birds of the Peace-Athabasca Delta and of the Lake Athabasca region. Canadian Wildlife Service. 32 pages.

Kushlan, J. A. 1993. Colonial waterbirds as biodindicators of environmental change. Colonial Waterbirds 16: 223-251.

Preble, E. A. 1908. A biological investigation of the Athabasca –Mackenzie region. North American Fauna 27. 574 pages.

Ryder, J. P. 1975. Egg-laying, egg-size and success in relation to immature-mature plumage of Ring-billed Gulls. Wilson Bulletin 87: 534-542.

Salt, W. R., and **J. R. Salt.** 1976. The birds of Alberta with their ranges in Saskatchewan and Manitoba. Hurtig Publishers, Edmonton. 488 pages.

Salt, W. R., and **A. L. Wilk.** 1958. The birds of Alberta. Department of Economic Affairs, Edmonton. 511 pages.

Salt, W. R., and **A. L. Wilk.** 1966. The birds of Alberta. 2nd revised edition. Queen's Printer, Edmonton, Alberta. 512 pages.

Seton, E. T. 1911. The Arctic Prairies. C. Scribner & Sons, New York. 415 pages.

Soper, J. D. 1942. The birds of Wood Buffalo Park and vicinity. Transactions Royal Canadian Institute 24: 19-97.

Tinbergen, N. 1960. The Herring Gull's world. 2nd edition. Basic Books, New York.

Vermeer, K. 1969. Egg measurements of California and Ring-billed Gull eggs at Miquelon Lake, Alberta, in 1965. Wilson Bulletin 81: 102-103.

Vermeer, K. 1970. Breeding biology of California and Ring-billed Gulls: a study of ecological adaptation to the inland habitat. Canadian Wildlife Service Report Series Number 12.

Weseloh, D. V. C., and **L. Cocks.** 1979. Recent nesting of the Caspian Tern at Egg Island, Lake Athabasca, Alberta. Blue Jay 37: 212-215.

Received 17 November 2009
Accepted 24 April 2010

Notes

Swimming Wolves, *Canis lupus*, Attack a Swimming Moose, *Alces alces*

P. A. JORDAN[1], R. O. PETERSON[2], and K. A. LEDOUX[1]

[1]Department of Fisheries, Wildlife, and Conservation Biology, University of Minnesota, 1980 Folwell Avenue, St. Paul, Minnesota 55108 USA

[2] School of Forest Resources and Environmental Science, Michigan Technological University, 1400 Townsend Drive, Houghton, Michigan 49931-1295 USA

Jordan, P. A., R. O. Peterson, and K. A. LeDoux. 2010. Swimming Wolves, *Canis lupus*, attack a swimming Moose, *Alces alces*. Canadian Field-Naturalist 124(1): 54–56.

In August 2008 at a small pond on Isle Royale, Michigan, we saw three Wolves (*Canis lupus)* run towards and leap at or onto a cow Moose (*Alces alces)* standing at the shore's edge in water ca. 1.7 m deep. The Moose swam out into the pond with the Wolves swimming in pursuit while attempting, with occasional success, to climb on the back of the Moose. The chase eventually moved out of our view, but a week later we found a Wolf-eaten cow on the pond's shoreline where we estimated it might have been killed. The animal was ca. 14-yr old with arthritic lesions in the pelvic region. This is apparently the first published report of swimming Wolves attacking and killing a swimming Moose, the kill likely having been made as the Moose emerged from the pond. Remains of a second kill in that pond were found shortly thereafter.

Key Words: Wolves, *Canis lupus*, Moose, *Alces alces*, swimming, killing, Isle Royale, Michigan.

Numerous observations of Wolves (*Canis lupus*) attacking Moose (*Alces alces*) have been published, mostly as seen from small planes during winter (Jordan et al. 1965; Mech 1966; Vucetich and Peterson 2009); but far fewer attacks have been seen during the snow-free months. Several reports, however, describe three Wolves driving Moose into water: one in winter after which a cow was killed upon emerging from a lake (Jordan et al. 1965), and three in summer (Borkholder and Schrage 1975; Nelson and Mech 1993; Nelson 2001) where, in each case, the Moose apparently escaped. In fall 2008 citizens reported to the Minnesota Department of Natural Resources seeing three swimming Wolves attack an adult cow Moose standing in ca. 1 m of water in a lake in northeastern Minnesota. At least one Wolf was on the cow's back biting at its neck. The observers scared the Wolves off, but were unable to save the Moose since it appeared to be "stuck in the mud." Presumably the Wolves could have returned and killed it. Other than Moose, reportedly a BBC video by Jeff Turner ca. 1991 in Wood Buffalo National Park shows swimming Wolves pursuing and subsequently killing a Bison (*Bison bison*) in a lake then feeding on it at the water's edge. Carbyn and Trottier (1988) generalize that bison being chased by Wolves will attempt escape by entering water bodies. Nelson and Mech (1984) observed a swimming Wolf kill a swimming White-tailed Deer (*Odocoileus virginiana*) in a lake in northeastern Minnesota. We report here our observation of swimming Wolves attacking and killing a swimming Moose, plus later evidence from the same pond that Wolves also swimming killed a Moose that was possibly standing in water < 2-m deep.

On 24 August 2008, at Isle Royale Michigan, we were on a bluff 0.8 km west of Saginaw Point (latitude 48°36', longitude 88°36'), overlooking an un-named, 1.7 ha, pond ca. 26 m below us. The pond was bordered by a flat meadow, beyond which were hardwoods and conifers (Figure 1). Linear distances were reconstructed from an aerial photo (Figure 1) showing two geo-referenced sampling points of known distance apart. The pond's perpendicular maxima were 245 and 115 m. The shoreline within our view (Figure 1) comprised vertical banks extending 1-1.5 m above the water. Water depth was estimated as >2 m in the middle and only ca 1.7 m nearer shore. The pond bottom was a muddy substrate of unknown softness.

We heard the moaning of a lone, adult cow Moose that was swimming towards the west shore (Figure 1 "B") and then stood at the edge while foraging on aquatic plants. It was in a depth of ca. 1.75 m, based on a still photo showing its back above the surface and assuming a shoulder-height of 185-195 cm (Bubenik 1997), but not accounting for its hooves probably being 5-10 cm into the substrate. Its hindquarters were ca. 1 m from the bank as it faced away from shore. Another lone cow, judged to be a yearling, was standing above on flat ground in the open some 40 m farther from us. No calves were seen.

We then saw three Wolves, all judged to be adults that were of similar size and color, running across the flat meadow directly toward the cow in the pond. We judged, based on the topography, that they could not have initially seen the cow below the shoreline bluff, so we speculated they had heard its vocalizations. Upon reaching the edge directly above the cow, the Wolves

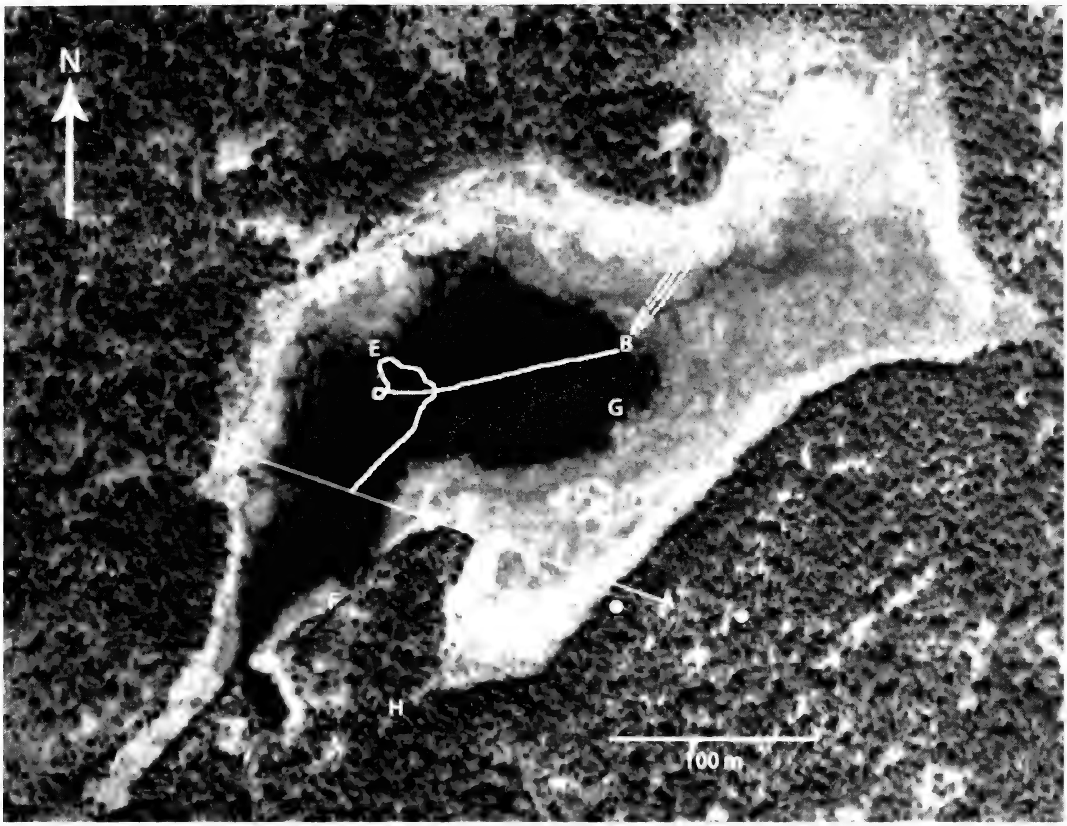


FIGURE 1. Aerial photo of the unnamed pond, Isle Royale National Park, MI. "A," the point from which we observed the chase, the straight line being the limit of our vision to the left, and the two circles are the fixed points of know distance apart; "B," the initial location of the chased cow Moose; "C" initial and final location of the second cow Moose, a suspected yearling of the chased cow, with its course, the lighter dotted line, showing where it appeared to follow the chase then returned to its original position; "D," approximately where the three Wolves were first seen by us, the heavy dotted lines being their running course toward the cow, and the solid line in the water is the course of the chase, with "E" being where the cow approached the shore and one Wolf briefly went on shore. "F" is the shoreline point where the carcass was found a week later; "G," where the carcass of a Wolf-eaten bull was found in the water two weeks later; and "H" where a second Wolf-eaten adult bull was found, probably killed somewhat before "G."

leapt into the water or directly on top of the Moose. The cow immediately headed away from shore, apparently swimming, though a mud trail behind indicated that its hooves were stirring up the substrate. We video-recorded the chase for some 4 minutes until the animals moved out of our view (Figure 1). The Wolves were unquestionably swimming throughout our observation, with one exception noted below. Our video footage reveals that at least two Wolves repeatedly mounted the cow's back each time for a few seconds and seemed to be reaching for and biting at its neck. The frequency of these mountings increased over the span of our observation. When a Wolf reached the base of the neck it was shaken off by the cow's vigorous, side-shaking of its head and neck. At the start, Wolves were swimming 5 m or less behind the Moose, but steadily closed to within 1-2 m. If any of their bites were drawing blood, this was not visible to us nor revealed in the video.

From the middle of the pond, the cow first headed to the shore farthest from us to within 1 m of a point where going ashore would be readily feasible, but then turned back towards the middle (Figure 1). At that point one Wolf that had been trailing the others took a few steps onto the shore, but jumped back in when the chased cow turned back. From there the chase moved to the center of the pond and then out of our view (Figure 1).

During the chase, the yearling cow on the far shore followed on land, apparently watching the chase until it was also out of our view (Figure 1). About 5-10 minutes later it returned to near its initial location. We are

not aware of other reports of a Moose appearing to follow the course of a predatory attack on another Moose (other than cows witnessing predation on their calves).

We stayed on the bluff some 10 minutes after the chase was out of sight. We heard a single loud sound resembling a growl or bark. We did not search the corner of the pond where the chase was headed, so did not know then how it ended. One week later, at a point on the shore towards which the chase was heading (Figure 1) we found a well-eaten carcass of a Wolf-killed cow. It was aged as ca. 14 yr and had significant arthritic degeneration in the pelvic region. On 16 October 2008, some 15 days after finding that cow, we discovered a Wolf-killed, bull Moose floating in the same pond, with one Wolf sitting on the still-intact carcass plus four pups and four adults being on the adjacent shore. We assumed by the carcass location that the Wolves had probably made the kill while swimming, though the Moose, if able to stand, might have been constrained from walking/running by its hooves being too far into a soft substrate. A third fresh carcass ("H", Figure 1), a bull Moose, was found inland 60 m from the first carcass (Figure 1) 10 days after the second find, but probably had been killed earlier. From telemetry data, all three attacks were likely by the regularly monitored "Chippewa Harbor Pack" which included one radio-collared member (Vucetich and Peterson 2009).

The two kills, that were both apparently by swimming Wolves, might represent a novel skill developed by this particular pack simply through trial and error. From Peterson's years of tracking Wolves and examining their kills during summer, it is notable that over the past couple years this pack had killed quite a few adults, many of which were in the vicinity of ponds or relatively small lakes. On the other hand, while aquatic attacks have not been reported as a common trait, paucity of such records during the warm season may simply reflect a low probability that such would be observed. At the same time, if Wolves in many areas have consistently been unsuccessful in swimming attacks, then such experience might lead to few such attempts being made, and hence this hunting strategy not being passed on to younger Wolves. Our observation will apparently be the first published account of swimming Wolves attacking and killing swimming Moose, although in the case observed, the kill was apparently just as the animal was coming on shore. The second carcass recovered clearly indicates a kill by Wolves that were swimming, but the Moose may have been standing in ca 1.5 m of water, possibly unable to move quickly due to being constrained in a soft substrate.

Acknowledgments

Significant advice and manuscript review were provided by L. David Mech and Michael Nelson. Logistic support was provided by Isle Royale National Park; travel was funded by the University of Minnesota Undergraduate Research Opportunity Program.

Documents Cited (marked * in text)

Vucetich, J. A., and **R. O. Peterson.** 2009. Ecological studies of wolves on Isle Royale. Annual reports accessed on 25 August 2009 at *www*.isleroyalewolf.ogr.

Literature Cited

Borkholder, B., and **M. Schrage.** 1997. The ultimate moose sighting. Boundary Waters Journal 11(3): 88.

Bubenik, A. B. 1997. Evolution, taxonomy, and morphophysiology. Pages 77-123 *in* Ecology and management of the North American moose. By A.W. Franzmann, and C. C. Schwartz. Smithsonian Institution Press. 733 pages.

Carbyn, L. N., and **T. Trottier.** 1988. Descriptions of wolf attacks on bison calves in Wood Buffalo National Park. Arctic 41: 297-330.

Jordan, P. A., P. C. Shelton, and **D. L. Allen.** 1967. Numbers, turnover, and social structure of the Isle Royale wolf population. American Zoologist 7: 233-252.

Nelson, M. E. 2001. Witnessing ancient survival instincts. International Wolf 11(2):23-24.

Nelson, M. E., and **L. D. Mech.** 1984. Observation of a swimming wolf killing a swimming deer. Journal of Mammalogy 65: 143-144.

Nelson, M. E., and **L. D. Mech.** 1993. Prey escaping wolves, *Canis lupus*, despite close proximity. Canadian Field-Naturalist 107: 245-246.

Received 3 November 2009
Accepted 2 October 2010

Spiked Saxifrage, *Saxifraga spicata*, Rediscovered in Canada After 110 Years

B. A. BENNETT[1] and S. WITHERS[2]

[1]Yukon Environment, Government of Yukon, Box 2703, Whitehorse, Yukon Y1A 2C6 Canada; e-mail: Bruce.Bennett@gov.yk.ca
[2]Laberge Environmental Services, Suite 1, 405 Ogilvie St., Whitehorse, Yukon Y1A 2S5 Canada; e-mail: stuwithers@xplornet.com

Bennett, B. A., and S. Withers. 2010. Spiked Saxifrage, *Saxifraga spicata,* rediscovered in Canada after 110 years. Canadian Field-Naturalist 124(1): 57–58.

Saxifraga spicata (*Micranthes spicata* (D. Don) Small), a large perennial showy saxifrage endemic to the unglaciated regions of Alaska and Yukon, was rediscovered after not having been seen in Canada for 110 years.

Key Words: Spiked Saxifrage, *Saxifraga spicata*, *Micranthes spicata*, Yukon Territory, endemism, rare vascular plant.

Stu Withers and Grant Lortie rediscovered the Spiked Saxifrage, *Saxifraga spicata* (D. Don) Small, on 15 July 2009 at Donahue Creek, Yukon Territory (63.21°N 139.51°W), near the creek's confluence with the Yukon River. This population is approximately 95 km up the Yukon River from the vicinity of the only previous Canadian collection and about 300 km (430 km by river) southeast of the next known extant population in Yukon-Charley Rivers National Park & Reserve, Alaska (University of Alaska, 2009).

It was first collected in Canada by John Berry Tarleton on an expedition to the Upper Yukon River in 1899. Tarleton spent the summer traveling from Skagway to Dawson collecting plants along the Yukon River. His collections are now housed at the New York Botanical Gardens. The exact location of this original collection remains a mystery, though we know it was collected "along mountain streams, near Indian River, August 3, 1899 (Tarleton, no. 176)." His collection was described as a new species – *Saxifraga galacifolia* Small (Britton and Rydberg 1901).

Eric Hultén in his valuable work, Flora of Alaska and Yukon (1941-1950), placed this new species in synonymy with *Saxifraga spicata* stating "The plant described by Small as *S. galacifolia* in no way differs from the rest."

Saxifraga spicata was described by David Don in 1822, from a collection made in 1778 by David Nelson, a member of Captain Cook's third voyage. It was collected on Sledge Island, Alaska on the southwest tip of the Seward Peninsula in the Bering Strait. The original collection was deposited in Sir Joseph Bank's Herbarium which is now found in the Natural History Museum (BM) in London, England (Figure 1).

Withers found fewer than 100 plants at Donahue Creek, a remote site that is only easily accessed by river, being over 100 km from the nearest road. Spiked Saxifrage grows on moist shaded stable stream banks and gravelly slopes that are usually not ice scoured, often under alders, though it is also known from moist ericaceous tundra in Alaska. It was found growing along the banks of the creek with shrubs including

FIGURE 1. Holotype of *Saxifragia spicata* D. Don. Courtesy of the Natural History Museum (BM) London, England.

Alnus viridis, *Viburnum edule*, *Rosa acicularis*, and *Ribes hudsonianum* and herbs such as *Aquilegia brevistyla*, *Galium boreale*, *Equisetum arvense*, and *Mertensia paniculata*. Spiked Saxifrage can grow 70 cm tall (Cody, 1996), has cream to yellow flowers about 1 cm across and rounded, serrated, hairy leaves up to 15 cm broad.

Though it had not been seen in over 100 years, botanists had not given up hope of rediscovering it. The plant is uncommon but not particularly rare in Alaska. There are still many areas of suitable habitat to search in Yukon and future surveys may reveal further populations. The collections will be housed at Agriculture and Agri-Food Canada (DAO) and B. A. Bennett (personal herbarium).

Documents Cited (marked * in text)

University of Alaska, Museum of the North. 2009. Arctos database. http://arctos.database.museum/SpecimenResults.cfm accessed 8 October 2009. Fairbanks, Alaska.

Literature Cited

Britton, N. L., and **P. A. Rydberg.** 1901. Contributions to the botany of the Yukon Territory. 4. An enumeration of the flowering plants collected by R. S. Williams and J. B. Tarleton. Bulletin of the New York Botanical Garden 2. 149-187

Cody, W. J. 1996. Flora of the Yukon Territory. NRC Research Press, Ottawa, Ontario, Canada. 643 pages.

Don, D. 1822. Transactions of the Linnean Society of London. 13 (2): 354.

Hooker, W. J. 1833. Flora Boreali-Americana; or, the botany of the northern parts of British America: compiled principally from the plants collected by Drs. Richardson and Drummond on the late northern expeditions, under command of Captain J. Franklin. London. [Page 251].

Hultén, E. 1941-1950. Flora of Alaska and Yukon, 1-10. Lunds Universitets Arsskrift N.F., Aud. 2. Volumes 37-46. 1902 pages.

Received 16 October 2009
Accepted 18 April 2010

Territorial Behavior of Short-eared Owls, *Asio flammeus,* at more than 1000 km North of their Current Breeding Range in Northeastern Canada: Evidence of Range Expansion?

JEAN-FRANÇOIS THERRIEN

Département de Biologie and Centre d'Études Nordiques, Université Laval, Québec G1V 0A6 Canada; e-mail: jean-francois.therrien.3@ulaval.ca

Therrien, Jean-François. 2010. Territorial behavior of Short-eared Owls, *Asio flammeus*, at more than 1000 km north of their current breeding range in northeastern Canada: evidence of range expansion? Canadian Field-Naturalist 124(1): 58–60.

A pair of Short-eared Owls was observed throughout the summer of 2008 showing territorial behavior more than 1000 km north of their known breeding range in north-eastern Canada. These observations might be related to high lemming densities and/or climate change occurring in the Arctic.

Key Words: Short-eared Owl, *Asio flammeus*, territorial behavior, range expansion.

Among North American Strigidae, the Short-eared Owl, *Asio flammeus*, is known for its patchy distribution and irruptive behavior (Wiggins et al. 2006*). This erratic behavior is thought to be related to the varying abundance of its main prey items: small mammals (Wiggins et al. 2006*). Since 1989, wildlife biologists have spent 3 months each summer (late-May to late-August) on Bylot Island (73°09.329'N, 79°58.111'W), in Sirmilik National Park, Nunavut, Canada (Figure 1). The main camp is located in a flat plain (approximately 70 km^2) which would appear, at first glance, to provide excellent habitat for nesting Short-eared Owls. Low elevation and a relatively dense cover of grasses, forbs and shrubs are the main features of the area. Lepage et al. (1998) published a complete list of the bird species seen on Bylot Island and adjacent Baffin Island, and recorded the species which are known to breed there. Before 2008, the only owl known from Bylot Island was the Snowy Owl and, even it, was only seen in years of high lemming abundance (Gauthier et al. 2004).

In 2008, two adult Short-eared Owls (most probably male and female given their slight but apparent difference in size and color) were observed at the start of the field season (4 June). Both birds were often seen from a distance throughout the summer. Both were hooting, mobbing and displaying territorial behavior as we walked toward a specific area. Both owls were also seen showing similar behaviors against adult Arctic Foxes (*Vulpes lagopus*) on many occasions. However, no nest or signs of young were found during our three visits to the core area. Short-eared Owl's nests are known to be well-camouflaged and hard to find. Moreover, a breeding pair of Arctic Foxes had their den within 250m of the area defended by the owls. The foxes might have destroyed the nest, if any, before we were able to spot it. Both male and female owls were seen until 12 August, our last visit to the area before camp closure. Seven regurgitated food pellets were found in the area occupied by the Short-eared Owls and were analyzed. Collared (*Dicrostonyx groenlandicus*) and Brown (*Lemmus sibiricus*) lemmings constituted respectively 63% and 37% of the 8 preys identified in the pellets. Lemming abundance was high in the study area in 2008, resulting in the presence of numerous Snowy

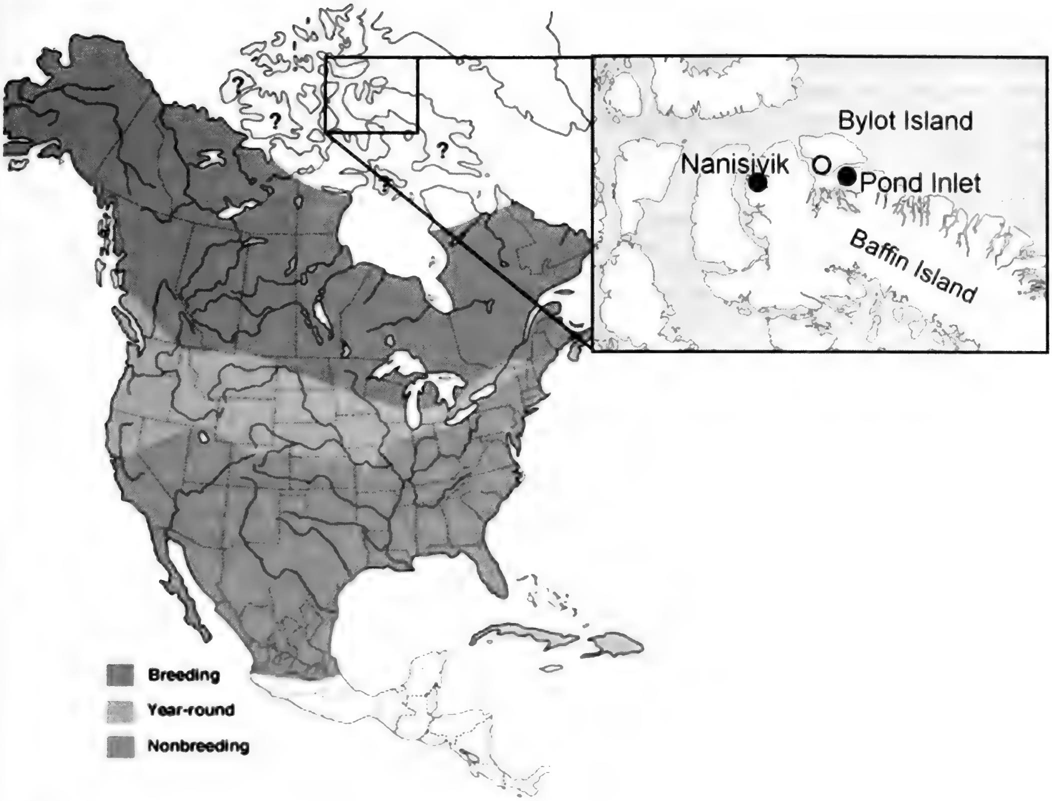


FIGURE 1. Actual known range of Short-eared Owls in North America with location of the observations on Bylot Island in summers 2008 and 2009 (open circle). Picture adapted from Wiggins et al. (2006*).

Owls' nests. In 2009, two adult Short-eared Owls were again seen on Bylot Island on 8 and 12 June. They did not, however, show territorial behavior and were not seen later on. Lemming abundance was low in 2009, as witnessed by the absence of Snowy Owls.

Conclusion

This note records Short-eared Owls showing territorial behavior, more than 1000 km to the north of its known range (Wiggins et al. 2006*). No Short-eared Owl was ever reported at such a latitude in the Northwest Territory/Nunavut Bird Checklist Survey of the Canadian Wildlife Service (K. Kardynal, personal communication, 20 May 2009). Discussions with residents of Pond Inlet suggest that this might be one of the first records of Short-eared Owl in the northern Baffin area. We thus believe that the breeding range of Short-eared Owls might include the northern edge of Baffin Island as well as Bylot Island in Eastern Canada. This observation follows the pattern of projected short-term impacts of climate change in the Arctic ecosystem (i.e. addition of new species and changes in the abundance and distribution of the species already present) (Hinzman et al. 2005, Fischlin et al. 2007). With climate change being especially evident in the high Arctic, as observed from the weather station of Bylot Island in the last decade (Dickey et al. 2008), such observations of species outside their known range might become the rule rather than exceptions. More interviews with elders and residents from other communities in the eastern Canadian Arctic could provide valuable insight about Short-eared Owls presence and behavior.

Acknowledgments

The Bylot Island Ecological Studies and Environmental Monitoring project is leaded since its beginning by Gilles Gauthier to whom I am truly grateful. I also acknowledge the community of Pond Inlet, the Hunters and Trappers Organisation of Pond Inlet, the Joint Park Management Committee of Sirmilik National Park and the Parks Canada staff in Pond Inlet for their assistance. Two anonymous reviewers improved earlier version of this manuscript. Financial partners include the International Polar Year program from the Department of Indian and Northern Affairs Canada, the Natural Sciences and Engineering Research Council of Canada, the Fond Québécois de Recherche sur la

Nature et les Technologies (FQRNT), the Centre d'études nordiques, Université Laval, and the network of Center of Excellence ArcticNet. Finally, this contribution could not have been realised without the financial assistance and support of the Polar Continental Shelf Project.

Documents Cited (marked * in text)

Wiggins, D. A., D. W. Holt, and **S. M. Leasure.** 2006. Short-eared Owl (*Asio flammeus*), The Birds of North America Online. *Edited by* A. Poole. Cornell Lab of Ornithology, Ithaca, New York; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/062.

Literature Cited

Dickey, M.-H., G. Gauthier, and **M.-C. Cadieux.** 2008. Climatic effects on the breeding phenology and reproductive success of an arctic-nesting goose species. Global Change Biology 14: 1973-1985.

Fischlin, A., G. F. Midgley, J. T. Price, R. Leemans, B. Gopal, C. Turley, M. D. A. Rounsevell, O. P. Dube, J. Tarazona, and **A. A. Velichko.** 2007. Ecosystems, their properties, goods, and services. Pages 211-272 *in* Climate Change 2007: Impacts, Adaptation and Vulnerability. *Edited by* M. L. Parry, O. F. Canziani, J. P. Palutikof, P. J. van der Linden, and C. E. Hanson. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge.

Gauthier, G., J. Bêty, J. F. Giroux, and **L. Rochefort.** 2004. Trophic interactions in a high Arctic snow goose colony. Integrative and Comparative Biology 44: 119-129.

Hinzman, L. D., N. D. Bettez, W. R. Bolton, F. S. Chapin, M. B. Dyurgerov, C. L. Fastie, B. Griffith, R. D. Hollister, A. Hope, H. P. Huntington, A. M. Jensen, G. J. Jia, T. Jorgenson, D. L. Kane, D. R. Klein, G. Kofinas, A. H. Lynch, A. H. Lloyd, A. D. McGuire, F. E. Nelson, W. C. Oechel, T. E. Osterkamp, C. H. Racine, V. E. Romanovsky, R. S. Stone, D. A. Stow, M. Sturm, C. E. Tweedie, G. L. Vourlitis, M. D. Walker, D. A. Walker, P. J. Webber, J. M. Welker, K. Winker, and **K. Yoshikawa.** 2005. Evidence and implications of recent climate change in northern Alaska and other arctic regions. Climatic Change 72: 251-298.

Lepage, D., D. N. Nettleship, and **A. Reed.** 1998. Birds of Bylot Island and adjacent Baffin Island, Northwest Territories, Canada, 1979 to 1997. Arctic 51: 125-141.

Received 16 October 2009
Accepted 25 May 2010

Book Reviews

Book Review Editor's Note: We are continuing to use the current currency codes. Thus Canadian dollars are CAD, U.S. dollars are USD, Euros are EUR, China Yuan Remimbi are CNY, Australian dollars are AUD and so on.

ZOOLOGY

Birds of Europe: Second Edition

By Lars Svensson. 2010. Princeton University Press, 41 William Street, Princeton, New Jersey 08540 USA. 416 pages. 29.95 USD Paper.

In 2000, I picked up a copy of the *Complete Guide to the Birds of Europe* by Lars Svensson. It was originally printed in Sweden, but had been translated and published in English. I thought it was a fabulous book, easily the best guide in my collection. There was a problem though. It was 32 cm by 22 cm by 3 cm, far to large to be used in the field. Part of the magic were the illustrations and by Killian Mullarney and Dan Zetterström.

A couple of year's later I borrowed a shrunken version that I used in Tunisia. It contained everything in the big book, just that it was reduced to fit a regular field guide format. This new book is the second, revised edition and it is field guide size [19 cm by 13.5 cm by 2.5 cm]

Birds of Europe is a bit of a misnomer as it covers North Africa, Turkey, Egypt and the Middle East. This means birds like Bald Ibis, Sooty Gull, Mourning Wheatear and Nile Valley Sunbird are given coverage in the main text. Also include here are the regularly-occurring stragglers like the American thrushes. In all, the book covers well over 900 species.

The publisher calls this book "this classic guide" and for once I think the hyperbole is right. The illustrations are wonderful and you need to go back to Archibald Thorburn (1860-1935), a wildlife artist who worked mostly in watercolour, to see art of this quality. Not only are the illustrations technically competent, but they capture the essence of the bird. Look at Hawk Owl, with its characteristic, coy over-the-shoulder look or the Goldfinch with its stare-ahead look [you can almost hear the thistle seed being ground in its bill].

But this art must be more than attractive; it must be accurate and it is. Look carefully and you will see the faint bar on the forewing of the Madeiran Storm Petrel or note the characteristic stance of the Black-and-white Warbler. Mullarney and Zetterström have also depicted the range of colour in variable birds like the Willow Warbler and Black-eared Wheatear [both of which have given me problems in the past]. Many birds are depicted in several poses or plumages. Little vignettes give key characteristics like the distinctive wing angle of the Rough-legged Hawk. All this detail helps develop an understanding of the elusive "jizz."

The text, while not as immediately eye-catching as the art, is also first class. It is written with efficiency and, where warranted, with humour. In the critical areas where identification is difficult, the text is precise and meaningful. For similar species like the Little Ringed Plover, Ringed Plover and Semi-palmated Plover the critical differences along with the potential pitfalls are described carefully. These factors, coupled with the superb, multiple illustrations make this a "classic guide" indeed.

While the text follows the European English nomenclature [murres are guillemots, longspurs are buntings etc.] it does use American loon instead of diver. This edition is updated to follow the recent changes in taxonomy. For example, Cory's Shearwater now includes Scopoli's Shearwater as an identifiable subspecies [although some authorities split it as a separate species. I have seen flocks in the Dardanelles]. Similar changes to include sub- and full-species can be found in gulls, waterfowl, thrushes warblers, flycatchers, shrikes and finches [including scoters, the "Herring" gulls, wheatears and "Orphean" warblers.] One change I do not like is the conformity to the current taxonomic order. It has become annoying to have the format of books constantly changing. I am used to the Peterson sequence so it is confusing not to be able to automatically open the guide at about the right place. Now you need use the index to see where the genus has moved. I like a recent suggestion by Howell and his coauthors in "Birding" [the American Birding Association's magazine] that field guides follow a logical order for field use, regardless of changes to the taxonomic sequence.

After the main text there are 10 pages of Vagrants – birds that have occurred a dozen or so times in 100 years. Most of these are illustrated. Then follows 3.5 pages of Accidentals [un-illustrated] – birds that have occurred less than three times. In addition there are two pages, illustrated, showing hybrid waterfowl.

To get this book in the smaller format everything is reduced in size, except the well-designed range maps. This means the font is small, and I need spectacles to read it. A few of the illustrations have been cut too. The result is a book you can carry in the field; well worth such sacrifices.

Is it perfect? Not really as I saw a few tiny items to question [I have never seen a Red-eyed Vireo quite that green.], but I think I would justify my wife's label of me as grumpy if I raised these points. This book is meant to be used to identify birds in the field with a high chance of being correct. It achieves this and more. If only other field guides were as good. Although meant for birdwatchers in Europe [in the broadest geographical sense] non-Europeans might want to spend the $30 [excellent value] just to be able to drool and dream.

ROY JOHN

2193 Emard Crescent, Ottawa, Ontario K1J 6K5 Canada

Bear Wrangler: Memoirs of an Alaska Pioneer Biologist

By W. Troyer. 2010. The University of Chicago Press, 1427 East 60th Street, Chicago, Illinois 60637 USA. 256 pages. 19.95 USD, Paper.

In 1951, Will Troyer began a 30-year career with the U.S. Department of the Interior. *Bear Wrangler* is an intimate story of Troyer's experiences as a pioneer biologist in the Alaskan wilderness. Troyer narrates his life story in 26 short but compelling chapters in the 250-page book. The most significant and memorable events highlight each chapter, which are organized chronologically and by themes (e.g., "Fish Cop", "Wrangling Kodiak Bears", "Managing the Kenai Refuge"). Charming black-and-white photographs are interspersed throughout the text providing a welcome visual backdrop to the memories and experiences that Troyer recounts.

Troyer's engaging prose shows just how passionate he is about nature; one can really sense his deep connection to the natural world as revealed in his words. He is certainly a keen-eyed and knowledgeable naturalist. Though some natural history observations are only briefly reported, many are intimately discussed with informative notes (e.g., his birding forays in the Yukon Delta National Wildlife Refuge, formerly the Clarence Rhode National Wildlife Refuge). No scientific names are used in the text, a somewhat curious omission since taxonomy is an integral component of studies in natural history, but certainly does not detract from the value of the information presented.

Troyer eventually landed his dream job as a wildlife biologist in Alaska, but experienced many hardships. Travelling and working in a rugged landscape like Alaska presented many challenges and hazards, some of which nearly cost him his life. Some of the inherent dangers that Troyer faced were associated with his work on brown bears (*Ursus arctos*) when he became manager of the Kodiak Island brown bear preserve in 1955. Studying and working with such large, powerful, and unpredictable carnivores always involves acknowledging and contending with certain risks; as a pioneer in brown bear field research in Alaska, Troyer was breaking new ground. Even so, Troyer freely admits that he and colleagues often took many unnecessary risks out in the field when anaesthetizing brown bears. Though the conduct of he and his assistants did not approach the controversial behaviour of other more (arguably) eccentric bear biologists (e.g., Timothy Treadwell), some actions did reflect rather poor judgement. As a professional biologist, I fully acknowledge and appreciate the need and pressure to acquire data out in the field. However, doing so at the expense of one's own safety (if not life), as well as that of others, is generally reckless and lamentable behaviour and is something that I (any many other biologists I know) do not condone. Troyer also took risks in some of his other Alaskan wilderness adventures. For example, his dogged determination in photographing mountain goats (*Oreamnos americanus*) by himself at Horn's Cliff almost resulted in him losing his right eye. Having worked in the field and experienced several close calls with eye injuries, I could certainly empathize with the feelings of angst, panic, and fear that Troyer articulates when he was facing the grim possibility of (partly) losing his vision. Some misadventures while learning to pilot some planes were also frightening recollections. One can argue that Troyer's daring and adventurous spirit served as a source of strength for him in his profession as a wildlife biologist in Alaska. However, that same spirit was also arguably a potential weakness of Troyer's character, and in the context of Alaska's sometimes harsh and unforgiving wilderness, it sometimes did him more harm than good.

Wildlife management was a different profession in the 1950s, with many practices reflecting the ignorance of humans toward the ecological integrity of nature. For example, predator control during that time involved putting out poisoned bait to kill wolves and coyotes without thought and consideration of the consequences of removing predators from ecosystems. Conservation biology and wildlife management are branches in the biological sciences that are intrinsically value laden. They are also intimately linked to politics. Hence, like politics, these fields can often be best described as an art of attempting to achieve compromise between conflicting parties – in this case,

humans and nature. Troyer recounts many such experiences where his struggles to keep Alaska wild sometimes came into conflict with the needs and wants of the local populace.

Altogether, Troyer provides an honest introspective account of his professional and personal life, one that abounds with passion, hard work, and gratitude. I recommend this title to anyone wishing to learn about the rigours of leading a challenging and rewarding career in wildlife management, especially in Alaska, one of the last truly great wilderness frontiers in America.

HOWARD M. HUYNH

Acadia University, Wolfville, Nova Scotia, B4P 2R6 Canada
Present address: Department of Biological Sciences, Texas Tech University, Lubbock, Texas 79049 USA.

The Grizzly Manifesto: In Defence of the Great Bear

By J. Gailus. 2010. Rocky Mountain Books, 406 13 Avenue NE, Calgary, Alberta T2E 1C2 Canada. 168 pages. 16.95 CAD, Cloth.

This delightful little book will probably make you very angry: It fully exposes and documents the poor actions by the government of Canada when it comes to the mis-managed grizzly bears in Alberta and the National Parks of Banff, Jasper etc. The text starts out kindly. It gives a well-balanced and nice overview on bear biology, human-bear co-evolution, some of the spirituality around bears, and what YtoY (Yellowstone to Yukon corridor) is and stands for. This publication is a true "Manifesto" (=crisp and clear with a sound message), and makes for a fascinating read for everyone and beyond naturalists. This manifesto turns indeed "grizzly" when Parks Canada and the provincial government of Alberta get described in more detail, and how they not only ignore their mandate, e.g., ecological integrity, but also grassroots citizen science. As this book shows, the state of the Canadian tax-paid entities these days often just represents a sad mix of an industrial buy-out, an uncritical top-down tradition by "the crown", and a lack of awareness and action, spiced up with non-achieving labour union arguments, and weak legal terminologies that have no teeth and which can hardly get quantified and assessed for performance. Dubious policies by the Canadian Association of Petroleum Producers (CAPP), the Canadian Pacific Railway, Weldwood industries operating on public lands, and similar "contractors" and "professional biologists" like D. Ealey are further named by the author, or how the Minister of Sustainable Development, T. Morton, single-handedly disbanded the entire Albertan Grizzly Bear Recovery Team. Gailus, a former journalist, did also a great investigation to explain the more or less successful model in U.S. National parks like Yellowstone and the U.S. Endangered Species Act (ESA), showing that "In Canada, our governments are failing us". Similar to L. Willcox in the U.S., it turns G. Stenhouse, B. Stelfox, V. Pissot and others into truly Canadian environmental heroes for getting fired or discriminated because they showed how bad roads are for bears (a fact the Alberta government opposes in order to keep business running at all costs), that bear extinction looms in less than 50 years, and that a full-blown development AND protection can never happily go hand-in-hand on a finite land base. This little and easy to read publication of 150 pages and 9 chapters (no photos or maps) presents Parks Canada and SARA (Species at Risk Act) as a national shame (cited expert claim: … "failed miserably"…) and as an insult to the global audience witnessing the extinction process in Canada first hand. All tourists and experts see it. The tragic bear biographies of "Mary" and "#56" presented in the text make that extremely clear: If you are a bear, the last thing you want is to live in an Alberta National Park like Banff (a true mortality sink) or on industrial forest land.

Consequently, this book calls for a revolution (a thing rarely heard of in Canada); to stop the Canadian laissez-faire attitude (à la "things will probably be all right"), to end the terror of the "policy wonks in Ottawa" and to stop the so conveniently "self-policing of the industry". It has, for instance, already resulted in the environmental fact that "Canada's record is one of the worst in the developed world". Canada does not handle well mass-murders, nor 'crimes against nature' (the Convention of Biological Diversity CBD 2010 targets have not been met by Canada). As this book thankfully elaborates for us, the governmental claims that Canada would be the world leader in biodiversity, and in species recovery (A. Latourelle, Parks Canada CEO) are easily exposed as incorrect and when growth in tourism and a short-term economy are the promoted goals instead: Canadians AND bears all deserve justice. "The arrogant disregard Canadian governments seem to have for both the democratic process and the natural resources they have been charged to protect" becomes obvious to all, and is now written in stone for the world to see.

This book's text can hardly be improved. But a reference to Alaska's T. Treadwell would perhaps have been good, and that The Wildlife Society (TWS) and others run a Steady State Economy initiative already for over a decade (not really existing in Canada though, apart from efforts by N. Dawe et al.), and which would make

for a very efficient solution to safe bears, wildlife and habitats in general, and in Alberta in particular. The scandalous oil sand issue is not mentioned, nor the Cadomine mine and hunting attitude fully tolerated by University research in Edmonton; Climate Change got also somewhat played down in the text. Impacts brought by globalization, as well as the poaching demands from China should have been mentioned.

"Oh Canada": she is currently in big turmoil, and right now is the time for a major improvement, instead of "...a cowardly abdication of its legal obligation" and global responsibilities.

FALK HUETTMANN

EWHALE lab, Institute of Arctic Biology, Biology & Wildlife Department, University of Alaska-Fairbanks (UAF), Alaska 99775 USA

Birds of Canada

By David M. Bird. 2010. Dorling Kindersley, (Represented by) Tourmaline Editions Inc., 662 King Street West, Suite 304, Toronto, Ontario M5V 1M7 Canada. 512 pages. $40 CAD.

Primarily covering the most common species in Canada, this photographic guide by David M. Bird (Director of Avian Science and Conservation at McGill) provides an excellent starting point for newcomers to both bird watching and the "Great White North". As a young, British ecologist, newly arrived from the rainforests of Ecuador, this book offered me a welcome introduction to the birds of North America.

In developing my interest in birds, I have previously used field guides containing illustrations rather than photos (*Collins Bird Guide: The Most Complete Guide to the Birds of Britain and Europe* by Svensson & Grant, and *Birds of Ecuador* by Ridgeley & Greenfield). Whereas illustrations and line drawings can simplify the key identification features, I initially found the photographs in *Birds of Canada* to be over-detailed and confusing, particularly with families such as the American Sparrows, Thrushes and the Wood-Warblers. However, the clear labelling provides excellent guidance to the important visual cues and the accompanying illustrations highlight things to look for in flight. The extra photographs of alternative/seasonal plumages and sexual dimorphism are useful, although on occasion seem to be lacking. More could also be made of subspecies and morphs, but perhaps this would be confusing for the newcomers that this book seems to be aimed at.

The first few pages provide a solid background to birds, describing their evolution, anatomy, flight, migration, courtship and reproduction. I found these sections to be clear and thorough, offering information appropriate to children, adults, novices and seasoned amateurs alike. There is also an excellent section detailing the main components of field identification and describing how to use the book. Introduction pages to each of the main groups provide an excellent starting point, illustrating features common throughout the families and describing general behaviours.

Each page thereafter is devoted to one of each of 435 commonest species in Canada (30 rarer species are presented later, four to a page). The large photographs and 1-page-per-species approach results in the book being much larger than it could have been. I also found this to slow up the process of identification, as you have to turn through many pages upon seeing an unrecognisable bird in the field, in comparison to other books which show multiple, closely-related species on one page (*Birds of Ecuador*, *Peterson Field Guide to Birds of North America* by Roger Tory Peterson). There are diagrams provided to illustrate flight patterns: a functional extra which I have not seen in other field guides. The maps on each page illustrate North and Central America as a whole, which is a nice way to learn about a bird's migration patterns, but the maps are small and it can take a while to determine the exact status of birds in the Maritimes or Southern Ontario for example. Adequate descriptions are used for songs and calls (never an easy task), although I did find more could have been included to do with the length of the notes (Black Capped Chickadee for example).

I liked the way in which the classification, size, social units, lifespan and (of particular value to me) conservation status for each species is clearly presented. Another nice touch is the box found on each page depicting two of the most likely species to confuse a newcomer. However, I did notice one or two instances of poor correlation. Despite the fact that on the Wood Thrush page, the Hermit Thrush is shown as being a potentially confusing species, there is no mention of the former on the latter's page. There is also the case of Boat-Tailed Grackle, which is shown as a similar species to the Common Grackle, but receives no mention among the rare or vagrant species, and according to other sources is quite unlikely to turn up in Canada.

There also appears to be a few errors in the distribution and status descriptions of the main birds. For example, there is no mention of the Burrowing Owl's precarious state in Canada, or of the recovery program that is being implemented to prevent its decline. Laughing Gulls are included among the 435 common species, but the map shows their only Canadian occurrence is during migration in parts of New Brunswick and Nova Scotia. There is no mention of the increases

in numbers of Ravens, Cardinals and Canada Geese, nor is the drop in Evening Grosbeaks and Brown Creepers noted.

The long list of vagrants (147) serves as a useful point of reference for incidences of confusion, and highlights how parts of Canada are blessed by an array of species during the migration season. Images could have been useful in this section, but would have increased the size of book further, and you can always look up these species online or in other guides. The comprehensive glossary that completes *Birds of Canada* is highly valuable to beginners. The index could have benefited from being split into common and scientific names.

Bulky, weighty and at times awkward to negotiate, I feel that this book is of no use in the field (despite the fact that it is lighter than *Birds of Ecuador*, which covers some 1600 species!). *Birds of Canada* however does serve as the perfect reference to leave at home and cross check against other field guides, which usually cover both the USA and Canada. Containing beautiful close-up's for identification in addition to photos of the birds in their natural habitat, I think that this book is of particular use to families and individuals developing an interest in bird watching, and is probably less valuable to those that can already describe themselves as "birders".

MATTHEW ILES

1431 Lakeshore Road, Apartment 308, Burlington, Ontario L7S 1B4 Canada

The Birds of Dalian: With Special Focus on Jinshitan National Holiday Resort

By T. Beeke. 2010. Bing Long Books. 180 pages. 98 Yuan (RMB). Available from the author (jinshitanbirding@yahoo.ca)

Naturalists worldwide play a great role in the documentation and conservation of species and habitats. This book presents us with such an heroic effort by a skilled naturalist. The Canadian author T. Beeke from British Columbia and living in China for over 6 years has just published a valuable and professional book documenting the avian diversity of a global birding spot: Dalian, located at the Northeastern Yellow Sea. As this nice little field guide shows, the Dalian region is home to c. 400 bird species, and of interest to birders year round (nesting season, fall and spring migrations, as well as a wintering ground). All of the featured species get described with three locally taken photos (usually in flight, perching and zoomed-in), with a descriptive text, and also showing the occurrence and species status in the area.

Besides its ice-free port, Dalian is also known for its Holiday Resort which has attracted tourists for decades. Bird sightings from adjacent areas and huge wetlands such as Lushun, Pikou, Zhuanghe, Wafangdian and Dandong are also included in this book. The current speed of development and contamination in China, and specifically in this region, is (literally) breathtaking: crucial nesting and stop-over habitats simply disappear within less than a year, and in front of the birder's eye! The devastating effects of a ruthless Global Economic Growth become obvious again. Another feature that makes Dalian known to birders is its species diversity, and the abundance of many migratory shorebirds; e.g., from Russia and Australia. Further, several international Arctic (!) gulls can be found wintering in the region (Vega Gull, Heuglin's Gull, Glaucous Gull).

The book is nice to read and does not claim to be a scientific treatise: instead it is designed for the beginner and even for interested school kids. Birders new to the area (and to the Chinese landscape) will benefit greatly from the four opening pages dealing with "Areas to look for birds: Forested Mountains, Coastal Mudflats, Agricultural Areas, Lakes, Ponds and Rivers". Among the over 180 species covered are for instance the beautiful Chinese cranes, egrets, raptors, warblers, flycatchers, thrushes, shrikes, buntings and the confusing warblers and pipits. Because up to 400 species occur in the area, a few more relevant species can probably be added to the book, and will make it into the next edition then (e.g., Coots, several Owls, Pied Harrier, Black Stork, Marsh Sandpiper, Siberian Rubythroat). But the endangered species such as Chinese Egret, Black-faced Spoonbill and Chinese Hill Warbler are also well featured by the author. The three page index of common English names proves helpful in the field (the author followed his own taxonomy).

"This book was put together with the goal of inspiring people to notice the birds around them". It's nice to learn that the locally involved author plans eventually for a Chinese (Mandarin) version of this neat book, and so that the local community can better appreciate its own natural wealth, and before it is all too late, over-developed and destroyed. So many of the formerly healthy and diverse landscapes in China are already widely impoverished and now lack their original set up: Huge regions are just dominated by domestic chicken, magpies, tree sparrows and common pheasants. In times of a massive globalization, the Dalian region and its precious biodiversity and documentation provided by an international Naturalist deserves our attention, support and protection.

FALK HUETTMANN

EWHALE lab, Institute of Arctic Biology, Biology & Wildlife Department, University of Alaska-Fairbanks (UAF), Alaska 99775 USA

Farmland Birds Across the World

Edited by W. Van der Weijden, P. Terwan, and A. Guldemond. 2010. Foundation Centre for Agriculture and Environment, Box 62, 4100 AB Culemborg, The Netherlands. 138 pages. 24 EUR, Cloth.

Several years ago, during a May bird count, my companion and driver suddenly sped up and said "Let us boot it through this desert." We had just left a riparian habitat where we had found several unusual species. We were now in open farmland and the only species we saw were House Sparrows. This coloured my view point for many years. Indeed I have found little diversity in Canada's vast acres of uni-crops – wheat, canola, flax, tobacco etc. Ranch land was always much better.

This new book brings a scientific, objective viewpoint to the importance of farmlands to birds. Be prepared to read a lot of statistical information, very important to a clear understanding. The authors include ALL farmlands in their analysis. They consider any type of farming from slash and burn to rice paddies, open range and coffee plantations. They include various methods of farming; conventional, crop rotation to organic. The results are surprising.

It seems that many birds have become dependant on farmland for at least part of their existence. Some birds have evolved as agriculture evolved to co-exist with humans. Indeed I find it odd to see some species like swallows nesting in cliffs and other wild places. This does not detract from the problem of lower species diversity in farm lands. However this book shows that some forms of farmland are far more bird-friendly than Canadian wheatfields. I was impressed by the list of species that use rice fields, for example.

This book identifies six basic types of farmland and devotes a chapter to each. The reader can find the distribution of each type along with the principle crop. The species that are affected are covered in a generic fashion, while specific species that have suffered or benefited are covered in vignette boxes. For example, the issues with the expanding goose population in Canada and elsewhere and the loss of Eurasian Skylarks are treated this way. Within each type the authors evaluate the differing methods of cultivation. Data from organic and conventional farms, for example, showed that the density for about half the species studied was higher on organic farms. As well the total abundance of all species was higher too. Similarly the cultivation systems for coffee and cacao are compared and a vignette box explains the role of the Black-throated Blue Warbler.

This book extremely well laid out. Clearly a lot of thought has gone into the design and this has made it easy to use. It is very well illustrated too. Examples of farmland and farming operations are depicted, allowing the reader to get a better sense of the nature of the farm type. There are many photos of the birds being discussed; beautiful, frame-filling artistic photos of fascinating birds. Where appropriate maps, charts and drawings are included.

It has been estimated that the numbers of all common birds has dropped by about 10% in the last 20 years, whereas the common farmland birds have declined by a whopping 50% in the same period. It is clear that formerly "common" farmland birds continue to decrease because of the effects of changing agricultural practices. While we cannot ignore the need for expanding and more efficient methods of providing food for the growing population, this book will give a better, more reasoned basis for the farming choices we will have to make.

This is an excellent, book that was fun to read, while raising some difficult and important issues. The global perspective is enlightening. You can buy it for pictures, but do not miss reading the text.

ROY JOHN

2193 Emard Crescent, Ottawa, Ontario K1J 6K5 Canada

The Eagle Watchers: Observing and Conserving Raptors Around the World

Edited by Ruth E. Tingay and Todd E. Katzner. 2010. Comstock Publishing Associates, a division of Cornell University Press, Sage House, 512 East State Street, Ithaca, New York 14850. 234 pages. $29.95 USD. Cloth.

There are academic ornithologists who do research and supervise graduate students, and there are avian field biologists. Of them all, the raptor researchers seem to be the most passionate, bold and fearless. Not least of the proof must be the hazards of raptor research such as gaining access to raptor nests and the young in them. Invariably the nests are on cliffs, sometimes with crumbling stone, or at the top of 30 metre high trees. On arrival at the nest, it is usually so wide and deep the climber needs to be an acrobat even to see into it. Handling raptors safely requires skill, strength and protection from beaks accustomed to tearing off mammal heads, and from talons which rip open guts with nonchalance. These hazards are obviously not the primary reasons why the devotees are so attached to their subjects. So it must be the graceful flying, the majesty, and the assured behaviour exhibited by the birds which are at the top of their food chain. It is that position in the food chain which makes them so vulnerable to local extinction when their prey is contaminated, such as consuming drugged cattle in India.

In the preface the editors write that the book is an "anthology of tales by people who study eagles in the wild". The first long chapter establishes eagle diversity,

ecology and conservation efforts. Each of the following 25 chapters of "The Eagle Watchers" is by a researcher about their specific raptor and describes a particular event during their work Every chapter starts with a page showing the principal statistics of the species, including its conservation status, followed by a brief biography and a photo of the researcher. It is unfortunate that the black-and-white photos are too poorly printed to identify the person or even distinguish whether they are male or female! Then follows the writer's essay on their memorable research encounter with their eagle. The essays vary in length from 5 to 14 pages. The authors mostly live in the countries where their research eagles are found, having turned their passion into their livelihood, and many of the researchers spent at least a short period at Hawk Mountain in Pennsylvania gaining experience. Profits stemming from the book sales will go to Hawk Mountain.

More than one chapter speculates on the reason for "cainism" – the siblicide when there is a second chick in some species, but there are no firm conclusions. A new behaviour by eagles has been attacking hang gliders – the gliders are fragile enough without this problem! Eagle deaths by wind turbines have been mitigated by pre-consultation on situating wind farms away from known eagle habitat and migration paths. And in The Karoo, South Africa, electricity pylons have been redesigned to deter eagles from perching and nesting. It seems that eagles perching on the pylons were causing electrical failure when their liquid faeces created an arc. Now who could have foreseen that?

One would have expected an index in an academic publication, let alone ensuring identifiable photographs. The small number of colour photos of eagles are fairly good. The target reader for the book would be a researcher in a different discipline or different bird species who needs a world-wide summary of some research and salient facts about eagles.

JANE ATKINSON

400 Kensington Avenue #201, Westmount, Quebec H3Y 3A2 Canada

Identifying Land Snails and Slugs in Canada

By F. Wayne Grimm, Robert G. Forsyth, Frederick W. Schueler, and Aleta Karstad. 2010. Published by the Canadian Food Inspection Agency (CFIA), 975 Boulevard St Joseph, Gatineau, Quebec, J8Z 1W8. 168 pages. No charge, call 1-800-442-2342 to order.

There is perhaps no more important development in the popularization of an organism group among both the general public and the scientific community than the publication of a well-designed and useful field guide. Accurate and user-friendly publications of this type have the opportunity to greatly expand the ranks of land snail enthusiasts, both amateur and professional alike and publication of field guides for these charming if underappreciated animals are too few and far between. I especially looked forward to the publication of *Identifying Land Snails and Slugs in Canada* by Grimm, Forsyth, Schueller and Karstad since I am familiar with the remarkable illustration skills of Aleta Karstad. In addition, Canada represents an excellent opportunity to generate a reliable, public-friendly guide to these organisms, given the fauna represents a manageable number (slightly less than 200) of native or naturalized species.

Unfortunately, *Identifying Land Snails and Slugs in Canada* does not rise to the challenge, and I fear it may do more to confound new malacologists than to aid them. Part of the problem is the fact that the book's title and mandate do not match. While the title suggests that this will be a guide to allow identification of the entire Canadian fauna, its species-level content on identification, biology, and ecology is limited to alien (and potential agricultural pest) species in the country. As a result, it is not possible to identify the native species that make up approximately 80% of the Canadian fauna. Even the reliable identification of some alien species will not be easy to accomplish, as comparison to native species is sometimes required.

Second, high quality images of representative species for each included genera are available only for slugs and those snails with shell diameters generally greater than 1 cm. All of the smaller taxa are represented by rather crude line drawings (at least in comparison to the magnificent slug figures), apparently lifted whole from Forsyth's *Land Snails of British Columbia*. This is highly unfortunate, as these small species make up approximately two-thirds of the Canadian terrestrial gastropod fauna, and typically well more than 90% of the individuals from any given site. Given the availability of hardware and software to allow fully focused full-color visible light microscopic images of tiny shells, and the presence of a superb biological illustrator among the authors, it is unfortunate to see the most common size class of Canadian land snails be given such short shrift.

Third, the generic level taxonomic keys do not appear to reliably allow for accurate assignment of individuals to the genus level. My expertise is in the pupillid land snails, and I found the keys to not work well for this group. For instance, some Canadian *Vertigo* species that lack apertural lamella/denticles (e.g. *V.* aff. *genesi*, *V. modesta ultima*) are forced in the key to the genus *Columella*. Also, albino *Vertigo* individuals (common within some *V. modesta* populations) will be forced into the genus *Gastrocopta*. The most common *Pupilla* from the Canadian arctic (*P. aff. pratensis*) is forced into the genus *Columella* because it does not possess a thickened callus in the aperture.

Lastly, I am concerned about the nomenclature used. It seems clear that the authors have chosen to follow the *Check-list of the Non-marine Molluscan Species of Northern, Atlantic and Central Europe* (CLECOM) by Faulkner et al. (2001) without considering whether these names are appropriate. As has been pointed out by Davis (2004) and Cameron et al. (2006), the CLECOM project is highly controversial, even in Europe. Among the most difficult issues in this checklist are the lack of justification for name revisions and the propensity for the CLECOM authors to be unrepentant splitters at genus and species levels. As a result, the taxonomic principles of Shileyko (1978, 1984), far from universally accepted even in Europe, are used without reservation in this field guide. This same approach is used on North American endemic groups that fall outside of the CLECOM region. It is thus common for the generic (and sometimes trivial names for a given taxon) to be altered from the recent literature, even when the integrity of that taxon itself is not questioned. As a case in point, consider the use of *Mediaappendix* to replace the genus name *Catinella*. No rationale for this change is given; no references are cited to defend this change. The elevation of this subgenus to genus level has never, from what I can ascertain, been used by any other North American workers in the group, including John Burch, the dean of succinead studies. For readers to know that the *Mediaappendix vermeta* of this guide is equivalent to *Catinella vermeta* or *Catinella avara* of other modern treatments would require considerable skill. I fear that as with CLECOM, many of the generic level changes in this guide may ultimately be found to be whimsical and based on short-lived phylogenetic hypotheses as recent DNA sequence data shows for "*Nearctula*" which turns out to simply be a rather typical "*Vertigo*". Changing names to reflect or promote the newest taxonomic "fad" generates unnecessary confusion and potential misinformation. This does the user a great disservice.

Given these limitations, I cannot recommend this book as an identification guide to Canadian land snails. However, where it does shine is as a treatment for introduced slugs. These species have only been cursorily treated in previous monographs, leaving most investigators to peruse Michael Kerney and Robert Cameron's *A Field Guide to the Land Snails of Britain and Northwest Europe* in an attempt to identify these invasive species. The color plates by Aleta Karlstad of the exotic slugs of Canada are stunning, and the keys to the genus *Arion* provide the user with an excellent resource in correctly identifying these species. As a result, it may be worthwhile for those interested in Canadian terrestrial gastropods to buy this book to simply serve as an invasive slug guide.

The fact that this publication does not in fact serve as a usable field guide for the Canadian terrestrial gastropod fauna is disappointing. Mollusks rank only behind arthropods in their contribution to global diversity. And, of the mollusks, terrestrial gastropod species (e.g., land snails and slugs) make a surprisingly large portion, with their estimated 40 000 species representing up to one-third of all known mollusks. Land snails are found from tropical forests to the arctic tundra, from deserts to peatlands, and from natural to urban jungles. Almost every yard, roadside verge, and forest will support at least some species, many with singularly beautiful shells. And yet, this group of species remains surprisingly unknown in North America.

There is no lack of resources available to allow identification of birds, mammals, reptiles, amphibians, fish, trees, grasses, wildflowers, butterflies, and etc. to the species (and often sub-species) level. And, at least partially as a result, there are legions of people who have taken an interest in these planetary neighbours, and may even speak out now and again when human actions threaten them. Kerney and Cameron's western European guide has been issued in English, French, and German versions. The fact that amateur land snail enthusiasts are more frequent 'across the pond' is due I am sure in part to the fact that this field guide exists. This has helped our European counterparts to be able to make local, national, and regional governments responsive to the plight of land snails. For instance, conservation groups held up construction of the A34 Newbury Bypass in Berkshire, England for almost three years due in part to the presence of the 3 mm tall *Vertigo moulinsiana* along the proposed right-of-way. I doubt this could have happened without the existence of Kerney and Cameron.

But, none of this can be said for North America, where terrestrial gastropods remain almost unknown to naturalists. I would be surprised if much more than 100 people across the continent could identify even half of their regional fauna. The general public remains almost completely ignorant of even the existence of these organisms. And, as long as they remain unknown and unappreciated, they will be given no consideration in terms of policy decisions. There is a crying need for more publications to make this diverse and interesting group accessible to a larger segment of our society, and I look forward to the day that this is ultimately done for the entirety of the Canadian fauna.

Literature Cited

Cameron, R. A. D., B. M. Pokryszko, A. Riedel, and **A. Wiktor.** 2006. Checklists, systematics and the CLECOM initiative: an alternative view from Europe. Malacologia. 49: 225-230.

Davis, G. M. 2004. Species check-lists: death or revival of the Nouvelle École? *Malacologia*. 46: 227-231.

Falkner, G., R. A. Bank, and **T. von Proschwitz.** 2001. Check-list of the non-marine molluscan species-group taxa of the states of northern, Atlantic and central Europe (CLECOM I). Heldia 4:1-76.

Shileyko, A. A. 1978. Nazemnye mollyuski nadsemeystva Helicoidea. Fauna SSSR. Mollyuski, III. 384 pages..

Shileyko, A. A. 1984. Nazemnye mollyuski podotryada Pupillina fauny SSSR (Gastropoda, Pulmonata, Geophila). Fauna SSSR. Mollyuski, III. 399 pages.

JEFFREY C. NEKOLA

Department of Biology, University of New Mexico, Albuquerque, New Mexico 87131 USA

ENVIRONMENT

Amphibian Ecology and Conservation: A Handbook of Techniques

Edited by Kenneth Dodd. 2010. Oxford University Press Inc., New York.

Amphibians, the original pioneering land vertebrates, have survived their displacement from former dominance by more advanced vertebrates as numerous and diverse, generally relatively small, forms. These include the familiar and widely distributed frogs, the northern temperate and tropical American salamanders, and the tropical caecilians. These, however, are now regarded by many leading researchers as faced with a new wave of extinctions due to increasing loss of habitat, chemical residues pollution, and the spread of devastating disease. As a consequence, their study and habitat management is widely pronounced as an immediate world conservation priority. It is estimated that of the 6400 modern species described to date, one-third are threatened and 168 are judged now extinct. As well, an unknown number of yet undescribed species may disappear before they are found.

The purpose of this book is present a comprehensive survey of the current state of research on amphibians. To accomplish this, editor Dodds has enlisted contributions from 52 herpetologists. Americans dominate, only nine are from elsewhere, one each residing in Australia, Brazil, Germany, France, Panama, Russia, Switzerland, Tanzania, and the United Kingdom. That none are from Canada does not fairly reflect the active research and conservation initiatives, past and current, here.

The text is divided into six parts containing 27 chapters in all. Part 1 is an overview on diversity and life history ending with why amphibian declines matter, and a chapter on field study objectives. Chapters in Part 2 concentrate on larvae and included chapters are on morphology, sampling, dietary assessments; mesocosms, and water quality criteria. Part 3 focuses on juveniles and adults containing chapters on measuring and marking post-metamorphs, egg mass and nest count, dietary assessments of adults, movement patterns and radiotelemetry, field enclosures and terrestrial cages. Part 4 deals with population: drift fences, coverboards and other traps, area-based surveys, rapid assessments of diversity, auditory monitoring of populations, and measuring habitats. Part 5 tackles communities in two chapters, one on diversity and similarity, the other on landscape ecology and GIS methods. Part 6 is on physiological ecology and genetics with chapters on field methods, models in field studies of temperature and moisture; genetics in field ecology conservation; selection of species and sampling areas; the importance to inference; capture-mark-recapture, removal sampling, occupancy models; quantifying abundance: counts, detection probabilities, and estimates; disease monitoring and biosecurity; and conservation and management. Each chapter has its own reference section which facilitates quick reference to studies cited. There are over 50 black-and-white photographs and diagrams and a number of tables scattered through the text where relevant.

Naturalists will find much of interest in the studies and approaches described which will further their perspective of past and current field research undertaken on amphibians. But its widest use will be as a technical reference for further scientific studies. As such its usefulness as a lecture and graduate studies reference will be great.

Surprisingly, although there are useful suggestions on ethics in research, there is no emphasis and little mention of the necessity of applying for permits for studies of at least some species in most jurisdictions. This exercise must precede research. Regulations vary widely between provinces, states, and countries. As well, these frequently change. A check must be made on current requirements and applications submitted months before planned initiation of any study. Early application is essential as there is a universal tendency for permit issuing authorities to act at glacial speed.

FRANCIS R. COOK

Researcher Emeritus, Canadian Museum of Nature, Ottawa, Ontario K1P 6P4 Canada

The Changing Arctic Landscape

By Ken Tape. 2010. The University of Chicago Press, 1427 East 60th Street, Chicago, Illinois 60637 USA. 132 pages. 35.00 USD Cloth.

The author, Ken Tape, has turned a very interesting idea into an intriguing book. He has collected as many old photographs of the Alaskan Arctic landscape as he can. He has then travelled to the same locations, searched for the exact location of the original photographer and then re-taken the photograph. This allows the reader to directly compare the way the landscape looked in years past to modern photographs. Generally the originals were taken at least 50 years ago, but some are much older.

For most, but not all, there are noticeable differences. Typically, there is a noticeable expansion of shrubs or

small trees. Places that had the typical, low-growing tundra vegetation are now shrubby. Where there were shrubs in the past now has a significant development in the size and extent of these plants.

To understand these modifications, Tape explains the impact of changes in the climate. He considers more or less snow, temperatures, rain, albedo, and permafrost. For example, a loss of permafrost causes slumping and bushes like to move into the little furrows left by this process. These explanations a carefully crafted and reveal a great deal of Arctic biology.

The photograph comparisons also document the reduction in size of northern glaciers. There are some carefully reconstituted panoramas from the past to compare to recent digital images. Where useful the author marks in arrows or lines to help orient the reader. To achieve these paired views the author has had to work very hard. First, he collected old photographs from explorers, geologists and institutions. Not all of these are useful as most were taken for specific objectives that do not relate to Tape's. Next, they had to be copied and perhaps joined to be valid for this exercise. Then the author had to journey back to the area shown and find the exact spot to take a repeat picture. Those who have plodded across Arctic terrain will know this is no easy task.

During his research Tape met some of the pioneers of Alaskan exploration, mostly geologists. He includes short background biographies of these people and their work, along with comments from his interviews. This is a delightful addition to the book and gives a human aspect to this dominantly scientific text. These accounts are charmingly illustrated with old photos. Where possible there is an adjacent, recent picture of these people.

I have a very tiny technical quibble. The authors research area is Alaska north of the Arctic Circle. Not all of this area is within the "Arctic" [The modified 10°C isotherm] as some parts are south of the sheltering Brooks Range.

This book is a very enjoyable read. The text, including the scientific explanations, is easy to follow and, while descriptive, does not waffle. The photographs are fun to explore and re-explore. It is also an important scientific text, for it is written with objectivity and is backed by hard data. I think this short [alas, too short] book should be read by all fans of the Arctic, students and those who say nay [or is that Ni?] to climate change. So I have to give the last word to the Knights who say Ni:

HEAD KNIGHT: We shall say 'ni' again to you if you do not appease us.

KING ARTHUR: Well, what is it you want?

HEAD KNIGHT: We want… a shrubbery!

[*Monty Python and the Holy Grail (1975)*]

Do we?

ROY JOHN

2193 Emard Crescent, Ottawa, Ontario K1J 6K5 Canada

One Step at a Time… A Tribute to William J. (Bill) Cody, 1922–2009

PAUL M. CATLING[1], BRUCE BENNETT[2], GISÈLE MITROW[1], FRANCIS R. COOK[3], and JACQUES CAYOUETTE[1]

[1]Agriculture and Agri-Food Canada, Environmental Health, Biodiversity, Saunders Building, Central Experimental Farm, Ottawa, Ontario K1A 0C6 Canada; e-mail: catlingp@agr.gc.ca
[2]Department of Environment, Government of Yukon, Box 2703, Whitehorse, Yukon Y1A 2C6 Canada; e-mail: Bruce.Bennett @gov.yk.ca
[3]R.R. 3, North Augusta, Ontario K0G 1R0 Canada

Catling, Paul M., Bruce Bennett, Gisèle Mitrow, Francis R. Cook, and Jacques Cayouette. 2010. One step at a time… a tribute to William J. (Bill) Cody, 1922–2009. Canadian Field-Naturalist 124(1): 71–96.

It is a typical day at the herbarium on the Central Experimental Farm in Ottawa in the spring of 2008 and Bill is coming in the front door of the Saunders Building. "How are you feeling today, Bill?" "One step at a time," he would say. He was tired after coming in for 62 years, but he never said so. He always just said, "one step at a time." In fact, Bill was always optimistic, and he was always ready with a joke or a few words of a song.

He was a dedicated and famous botanist and a very enthusiastic team member. Bill made the world a better place, and it was a very sad day when he passed away on Monday, 23 March 2009, following a stroke. Bill (Figure 1) actually retired from his job with Agriculture and Agri-Food Canada (AAFC) in 1987 at 65 after 41 years of service, but he continued to come in and work every day as an honorary research associate until 2006, and then he came in twice a week until the spring of 2008, a total of 21 years of retirement service.

Bill is widely known for his botanical work in the north and as curator of the largest collection of dried plants in Canada, and as Business Manager of *The Canadian Field-Naturalist* for nearly 60 years. Many have heard his name in connection with the awards that he earned. These include Honorary Member of the Ottawa Field-Naturalist Club in 1979, the prestigious Canadian Botanical Association Lawson Medal in 1997, a Queen's Golden Jubilee Commemorative Medal in 2002, the Yukon Biodiversity Awareness Award in 2006, the Richards Education Award, a Distinguished Technical Communications Award, an honorary doctoral degree from McMaster University, and various service awards. For many years into the future, people will want to know more about Bill and to trace his work. Here we have encapsulated a lifetime in several pages. Bill's story is a very interesting one that relates to major historical events and important times in Canada, but it is also informative and inspiring because it demonstrates how a single person can make a huge difference.

There are three lists of references at the end of this document. The first is the Literature Cited, where Bill is not an author. The second list is of Bill's research publications (Appendix 1). Where any of these are cited in the text, their appearance is indicated by an asterisk (*). The third list includes Bill's miscellaneous publications (Appendix 2). Few of these are cited but where they are, they are followed by two asterisks (**). Over the years and after his death, a number of articles (all in the Literature Cited) were written about Bill, including Taylor (1969), Anonymous (1980), Cook (1987), Catling (1991), Pope (1997), Darbyshire (1998), Darbyshire and Taylor (1999), Anonymous (2003), Catling (2003), Anonymous (2004a,b), Benner (2005), Anonymous (2007, 2008), Bennett and Catling (2009), Catling (2009), Catling et al. (2009a), Cayouette (2009), McLachlan Hamilton (2010), Pope (2010) and Cook (2010).

The early days

Bill was born in Hamilton on 2 December 1922. His father, William Macpherson Cody, was a doctor, actually the first appointed anaesthetist at Hamilton General Hospital. His mother Ola (Ola May Beatty) was a nurse at the same hospital. Bill grew up in Hamilton, in a house opposite Gage Park, and he later lived on Wentworth Street. He loved it, and he loved the Niagara Peninsula, where he worked as a young man on a fruit farm owned by his uncle Bruce near St. Davids. He made his first botanical collections in this region.

Bill attended McMaster University. Botany professor Dr. Lulu Odell Gaiser was responsible for Bill's developing a love of botany. He received his B.A. from McMaster University in 1946 and joined what is now the AAFC the same year after working during the summer as a land use soil surveyor in southern Ontario for the Ontario Department of Planning and Development. As well as being Canada's first cytotaxonomist, Gaiser was an exceptional teacher (Moore and Grant 1965). After taking her taxonomy course, Bill helped her to look after her plant collection (which was transferred to the Royal Botanical Gardens after she retired). She suggested to Bill that he send an application for employment to the herbarium of the federal Department of Agriculture in Ottawa. There were two plant taxon-

omists on staff at the time, Harold Senn (Cody 1997*) and Ray Moore (Cody et al. 1986*), both of them students of Gaiser's and graduates of McMaster. With Gaiser's earlier communications and current recommendation, they already knew a lot about Bill. Naturally he got the job working as assistant to the curator, Harold Senn, and he started work in the herbarium on 1 October 1946.

Bill's wife and family, and a friend and a church

Bill married Lois Jean Wright (from Shanly, Ontario) in 1950. They had five children, David (wife Eija), Margaret, Leslie (husband Roland Durocher), Douglas (wife Laurie) and Gordon (wife Mandy). His family was always a major focus, and many of Bill's closest friends find inspiration in the way he put his life together. Lois passed away on 18 March 1998 after 47 and a half years of marriage. Bill was also predeceased by his sister, Elizabeth Marion Cody (Guzwell). See page 59 in the 1954 directory of the Cody family (International Cody Family Association) for more details.

Bill's family was proud of his scientific achievements but, much more than that, his family was a great help. Lois worked part-time for *The Canadian Field-Naturalist*. She also served as treasurer's assistant from 1968 to 1995 and received the 1988 OFNC Service Award. Lois was also a long-time Girl Guide leader and had numerous leadership positions and responsibilities. It is sometimes said that behind every great man is a great woman, and Bill drew much of his inspiration from a great woman who was beside him. No shadow was cast. Bill's children also took interest in his work. Four collected with him in the north, and Leslie compiled indexes for *The Canadian Field-Naturalist*. With skill in typing and word processing, she also processed many of Bill's publications and correspondence for him, particularly after he retired.

People sometimes called Bill "Buffalo Bill", perhaps because of his association with wild and distant places, but it is not so much of a stretch. Legendary Buffalo Bill Cody (William Frederick Cody, e.g., see Walsh and Salsbury 1928) was a second cousin of Bill's great-grandfather (Bill's second cousin three times removed). The Cody family is well connected. They have a newsletter: *The Genealogical and Historical REVIEW of the International Cody Family Association*. Forty-two annual volumes of this newsletter have been produced. A reunion is organized somewhere in North America every other year. The 2006 reunion was held in Cody, Wyoming. Bill's ancestry can be traced back to one of the islands between France and England and afterwards to New England (Cody 1954).

Bill Cody was a very reliable friend. He was five years old when he met Robert Noble Edward Haughton, then four, sliding down a veranda railing in Hamilton, and they stayed in constant contact until Bill's death. Robert followed in his father's footsteps, working for the Bell telephone company. Bill's friends included the broad sweep of society. Bill was also a very faithful member of Trinity United Church in Ottawa. Here he served in the choir for decades, and his various science awards were often on display in the church hall.

Working at Agriculture Canada

Bill began work with the Department of Agriculture (now Agriculture and Agri-Food Canada) as a junior agricultural assistant working with collections curator Harold Senn in 1946. Later he was appointed senior technical officer, became curator in 1959, and in 1967 was promoted to research scientist. This classification was initiated the year before for researchers who had a Ph.D., but Bill's outstanding accomplishments at that time were judged by his colleagues and the science arm of the federal civil service to warrant treatment at the Ph.D. level. Bill was among the first scientists without a Ph.D. in the civil service to have their work so recognized.

Curating

The Plant Research Institute was created in 1959, and Bill was made curator of the herbarium. He supervised its growth from 370 305 to 800 000 specimens by 1987, when Paul Catling assumed the curatorial responsibility. This collection (Figure 2), now numbering 1.5 million specimens, is the largest of its kind in Canada. It is part of an international network allowing plant material to be borrowed, and it serves research, especially taxonomic research, worldwide. It has become a major tool of AAFC in the identification of economically important plants in connection with the management of invasive plants and enforcement of federal regulations. It also serves as a place where vouchers of material used in scientific studies are preserved. Many thousands of specimens that Bill collected in the northern wilderness under extreme and dangerous conditions are part of this collection, and they serve as vouchers for his numerous publications and books. These specimens have been used in hundreds of plant classification studies.

Bill's job as curator for 29 years included supervising the staff that prepared the material (labelling, mounting, inserting), preparing a budget to obtain supplies, keeping records (Figure 3), responding to requests for loans and information, managing the exchange program (Figure 4), explaining the operation and value of the collection to upper management, making sure that specimens were correctly filed, and assisting visitors. Bill continued to assist with all of these curatorial tasks for 20 years after he stepped down as curator. This was an enormous help at a time when staffing decreased even as the collection was increasing in size and as use of the collection increased. The certificate of appreciation that Bill received each year as an honorary research associate was an embar-

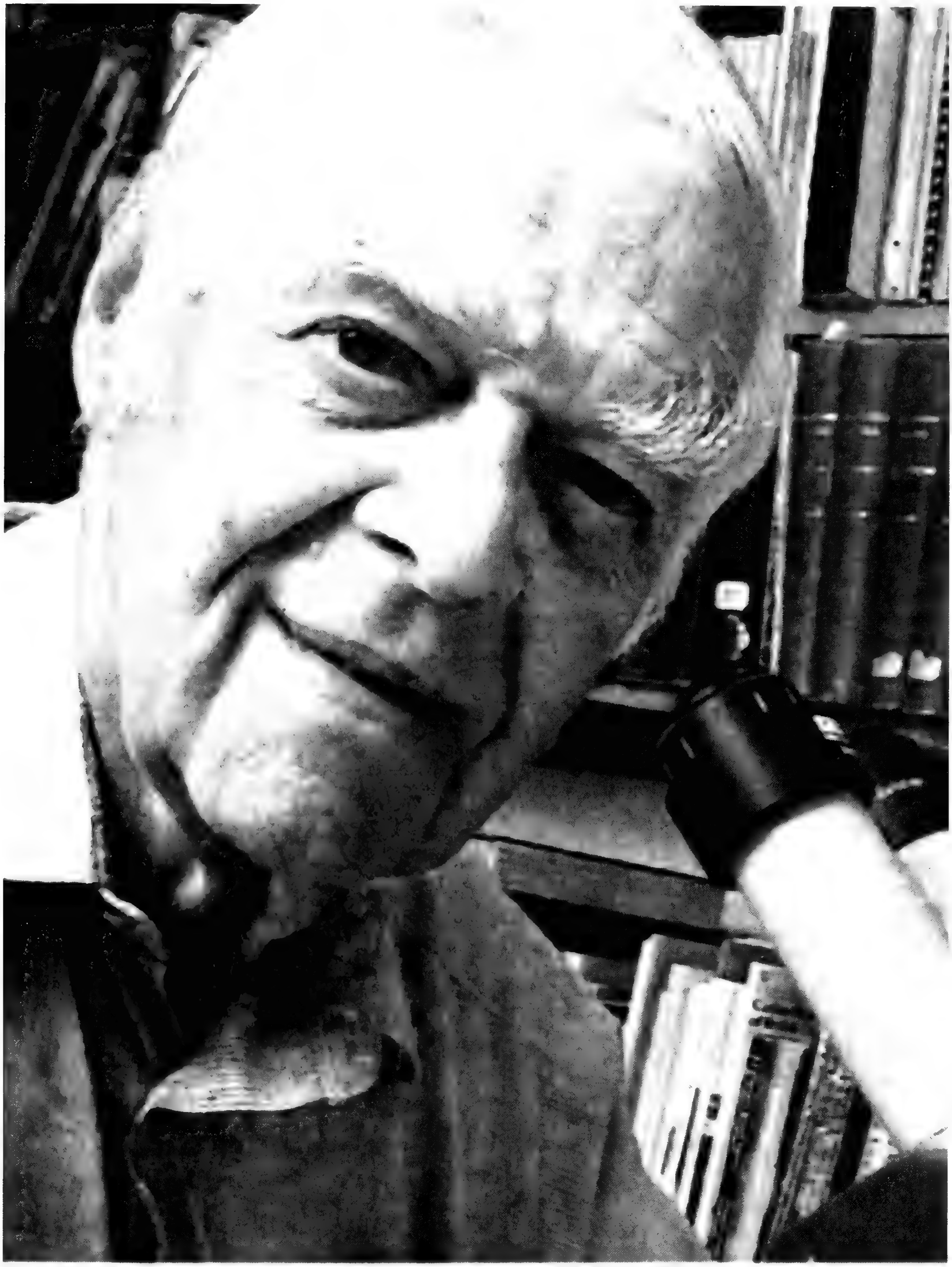


FIGURE 1. Bill Cody at his microscope. Photo taken in the Saunders Building, Central Experimental Farm, ca. 2000. Photographer unknown.

rassingly small token of thanks for his huge curatorial contribution. A good curator has a strong and unselfish dedication to a collection, and this can be a rare commodity in a competitive research centre, where ego seeks the recognition that comes with research results.

As well as contributing more than anyone else to the general development of the collection, Bill was instrumental in a number of very important and major improvements. For example, when forcing specimens into the limited space threatened to damage them,

Bill played a key role in 1986 in the development of a space-saving automatic compactor system that made substantial new space available and reduced costs (Cody 1986b*; Parmelee and Cody 1986*; Barr et al. 1987*). It was a model system at the time and one of the first in Canada.

In 1992, Bill assisted with the development of a climate control system that was installed to maintain temperature and humidity levels that prevent insect pests from consuming preserved plant material. This avoids the health hazards associated with periodic fumigations using poisonous chemicals. The herbarium was one of the first in Canada to adopt a climate control system to protect specimens and ensure the safety of staff by making chemical fumigation unnecessary.

The herbarium has been a general public focus of scientific activity on the Central Experimental Farm and has had many thousands of visitors. More importantly, it has developed into an extremely valuable tool of research and a service with hundreds of clients and users each year. More than anyone else, we have Bill Cody to thank for this. For more information on the collection, see Catling and Dang (1992) and Catling et al. (2009b).

Publications overview

Bill's first peer-reviewed paper was published in 1950 in *The Canadian Field-Naturalist*, and he went on to produce a total of 145 peer-reviewed journal articles and books and 16 reports (Appendix 1). Among his larger contributions are *Ferns of the Ottawa District* (Cody 1956*, revised Cody 1978a*, issued in French in 1980*), *Vascular Plants of Continental Northwest Territories* (Porsild and Cody 1980*), *Plants of Riding Mountain National Park, Manitoba* (Cody 1988b*, both English and French versions), *Ferns and Fern allies of Canada* (Cody and Britton 1989*, both English and French versions), *Systematics in Agriculture Canada at Ottawa 1886-1986* (Cody et al. 1986*), and *Flora of the Yukon Territory* (Cody 1996*, revised Cody 2000*). These books and the journal articles had a major impact. They are described in detail below under major headings "the North" (including floristic work in Yukon and the Northwest Territories) and "the South" (including work on ferns, parks inventories, and southern Ontario phytogeography). In his various publications, Bill named 16 taxa and made 30 taxonomic transfers (Appendix 3).

Bill's publications reflect the changing trends in systematic botany. During the 1960s and 1970s, when chromosome numbers were important in establishing groups and relationships and the Plant Research Institute was playing a key role, Bill cooperatively produced nine articles reporting chromosome numbers. Bill's reports include some valuable compilations. His production of the catalogue of 4500 type specimens in the National Vascular Plant Collection [DAO: Department of Agriculture Ottawa] (Cody 1996c*) is

FIGURE 2. Bill Cody demonstrating a plant specimen in the Agriculture and Agri-Food Canada National Collection of Vascular Plants that he was largely instrumental in developing. Photo taken in the Saunders Building, Central Experimental Farm, ca. 2000. Photographer unknown.

particularly valuable and has been extensively used by plant taxonomists worldwide. Bill edited Gillett's index to *The Canadian Field-Naturalist* and its predecessors (Gillett 1980). This greatly facilitated recovery of information from older volumes. Bill's reports and other publications also contributed much to conservation. He helped with descriptions of important sites in the north for the International Biological Program and he proposed ecological reserves (Simmons and Cody 1974*). The information that he provided on rare plants (Cody 1979*; McJannet et al. 1995*) has contributed to their conservation.

Bill reviewed many hundreds of manuscripts for journal editors and colleagues. This is not unusual for a scientist, but there was something special about the way Bill did it. He always stopped his own work and gave the review priority. He was the person that you could take something to and say, "I need a review of this in an hour," and you would have it back in 30 minutes. He also reviewed chapters for the multi-volume Flora of North America project developed by the Missouri Botanical Garden.

FIGURE 3. Bill Cody keeping herbarium records in the 1960s. This photo was likely taken in the Botany Building. The herbarium was moved to the Saunders Building in 1969. Photographer unknown.

Bill produced 180 miscellaneous publications (Appendix 2), including 154 non-refereed book reviews), 11 seed lists, and 15 encyclopaedia contributions. Most of the books reviewed were identification guides to the plants of different regions. They covered various provinces, states, or regions of Canada, the United States, and countries in Europe. They included floristic lists; regional rare plant contributions; lists of common names; vegetation studies; books or publications on ferns, trees, shrubs; various monographs on plants; botanical exploration; and history. These reviews were very helpful in drawing attention to new information that had become available in the days before information could be searched for on the Web.

The seed lists (*Index Seminum*) were produced from 1963 to 1973. After the 1950s, it was customary for botanical institutions to gather seeds and produce lists of the species for which seeds were available. Seeds were available to anyone who requested them. Research centres and botanical gardens around the world exchanged lists and obtained plants for research and horticulture. The lists that Bill coordinated and produced on behalf of the Department of Agriculture included hundreds of species and were 20–30 pages in length. They were a significant contribution, enabling Canada to participate in the national network. Important material of crop plants for research was obtained this way. Some of the unusual trees in the Dominion Arboretum on the Central Experimental Farm can be traced back to the days of the seed exchange.

Most of Bill's journal articles were published here in *The Canadian Field-Naturalist*, including 81 and 726 pages (with his final Yukon contribution in this issue), almost certainly setting a record. He also published a number of articles in the *Canadian Journal of Botany*, *Le Naturaliste canadien*, *Rhodora*, and *Taxon*, and a smaller number in numerous other journals and bulletins, including the *American Fern Journal*, the *Bulletin of the Torrey Botanical Club*, the *Blue Jay*, *Phytochemistry*, the *Canadian Journal of Plant Science*, the *Canadian Botanical Association Bulletin*, *Syllogeus*, the *Plant Press*, *Park News Magazine*, *Quatre-Temps*, *Herbarium News*, *Madroño*, and *Trail & Landscape*.

Much of Bill's work was done prior to the 1980s, before computers and word processing, when writing took longer. He had an Underwood typewriter with its ink ribbon as well as a bottle of white correction fluid, and he used both for some of his work until 2007. He also shared the typewriter with others when the modern equipment broke down but never touched the computer some well-meaning colleagues eventually had placed in his office. He willingly had staff and Leslie (after he had retired) enter his manuscripts on their computers as electronic methods became more popular.

Bill had an interest in remembering and honouring his co-workers. He wrote six tributes to botanists he had worked with: Ralph Anthony Ludwig (Cody 1977*), Alf Erling Porsild (Soper and Cody 1978a,b*; Cody 1985g**), Bernard Boivin (Cody 1985*; Cody and Cayouette 1986*; Cayouette and Cody 1989*), James Alexander Calder (Cody and Cayouette 1991*), Harold Archie Senn (Cody 1997*), and Hugh Miller Raup (Cody 1998a*). All this, as well as his review of systematics in Agriculture Canada (Cody et al. 1986*), represents a valuable contribution to botanical history in Canada.

FIGURE 4. Bill Cody sorting exchanges. Photo taken in the Saunders Building during the 1960s at the Central Experimental Farm. Photographer unknown.

Collections and identifications

Bill's earliest collections were made while he was a student at McMaster University, prior to 1946. These collections were from the Niagara Peninsula near St. Davids, from the Niagara Escarpment above Hamilton, and from Stoney Creek. They are preserved in the herbarium of the Royal Botanical Gardens in Hamilton. All of Bill's later collections are in the National Vascular Plant Collection of Agriculture and Agri-Food Canada (international collection acronym: DAO).

Over the period of his life, Bill collected approximately 40 000 specimens. It is estimated that at least 30 000 of these resulted from his 17 expeditions to the north (see below). The remaining 10 000 specimens are from southern Canada and especially from Ontario and Manitoba in connection with floristic inventories of Riding Mountain National Park in Manitoba (Cody 1988b*) and St. Lawrence Islands National Park in Ontario (Cody 1975b*, 1978b*; McNeill and Cody 1978*; Boivin 1980). Label data for some of his collections are available online; for example, 71 specimens collected by Bill are listed in the online catalogue of 4500 type specimens (Catling et al. 2009b). Other specimens collected by Bill will be available as images in a virtual herbarium of the Northwest Territories that may soon be available online.

Many people assisted Bill in collecting, and these major collaborators are listed elsewhere. An easily overlooked group of associate collectors was his family. Bill was very dedicated to improving the plant collection and no family expedition was a success without an addition to it.

Bill often collected duplicates for exchange with other research centres, and these have been distributed around the world. Exchanges may have brought as many as 200 000 specimens in to DAO, and they contributed greatly to its development as the best collection representing all of Canada. Through exchanges the herbarium became an outstanding collection representing the temperate regions of the world and has an especially good collection of weeds, crops, and crop relatives. Through his duplicates, W. J. Cody is listed as one of the important contributors to the herbarium of the Institut botanique de l'Université de Montréal, now the Herbier Marie-Victorin at the Institut de recherche en biologie végétale (MT) (Boivin 1980).

One of Bill's larger post-retirement contributions was the identification of many thousands of specimens. Each year he provided an enormous amount of information on plants to the agricultural sector, natural resources staff, wildlife biologists, native people and landscape planners as a contribution to the AAFC Vascular Plant National Identification Service.

The north

Bill's contribution to Canada and botanical research was enormous, and much of it had to do with the Canadian north. Both to honour Bill and to assist students of Canadian botany, his northern legacy has been outlined along with a list of his 73 scientific publications concerning the Northwest Territories, Nunavut and Yukon (Bennett and Catling 2009). The following text is mostly derived from that source. For most of the period of Bill's work in the north, Nunavut had not yet been established and much of the information about that territory is therefore included under "Northwest Territories."

Before Bill

In 1948, the most important and extensive collections made in the continental Northwest Territories were still those that had been made by surgeon-naturalist Sir John Richardson between the years 1819 and 1827 as part of Sir John Franklin's first and second expeditions to the Arctic to find the Northwest Passage (Pringle 1995). In all, Richardson collected 474 species of flowering plants and ferns that later appeared in W. J. Hooker's classic *Flora Boreali-Americana*. This was a third of the species known today.

Prior to the middle of the 20th century, comprehensive information on the flora of the Yukon and continental Northwest Territories was just emerging, mainly from outside the country. It included Nicholas Polunin's Botany of the Canadian eastern Arctic (1940) as well as J. P. Anderson's papers on the flora of Alaska and adjacent parts of Canada (1943–1950) and Eric Hultén's Flora of Alaska and Yukon (1941–1950 and published with brief descriptions, maps and keys in 1968). Alf Erling Porsild had written several works, including Materials for a flora of the continental Northwest Territories of Canada (1943) and Alpine flora of the east slope of Mackenzie Mountains, Northwest Territories (1945). A major contribution was Raup's Botany of southwestern Mackenzie (1947).

Although some of the collections were made by specialized botanists focused on making a complete regional inventory, most of the early plant collections were made opportunistically by explorers, geologists, missionaries, and general naturalists (Pringle 1995). Apart from the Mackenzie Mountains, which were explored as a consequence of the development of the Canol Road, and Raup's work, there had been very little comprehensive botanical exploration of northwestern Canada at this time (for useful reviews, see Porsild (1943), Porsild and Cody (1980*) and Cody (2000a*)). Despite having been included in regional floras, the plants of northwestern Canada were still not well known.

The time was right

Quite often good science is carried on the crest of a political and/or economic wave, and this was true in the middle and later 20th century, when two events resulted in great attention to Canada's northern sovereignty. These were the development of the oil and gas industry in the north and the concern over attack

across the North Pole. It was a period of conflict, tension, and competition with the Soviet Union. During this time the Distant Early Warning Line (DEW line), a series of radar stations, was established across the north to detect incoming Soviet bombers. Defence Research Board, Department of National Defence, cooperatively with the federal Department of Agriculture, undertook a major survey of biting insects in 1947 (Freeman 1954, 1959), because biting insects are so abundant at certain times in the north that human activity is severely restricted. These insect studies required the involvement of botanists to describe the habitat, and this was the basis for Bill Cody's first trip to the north, in 1948. The insect research also supported several other botanical surveys by expert botanists, such as James A. Calder's survey around Dawson in 1949 (Cody and Cayouette 1991*) and John M. Gillett's surveys near Watson Lake and Whitehorse the same year. The botanical results of the northern insect survey project were included in a series of reports by the Defence Research Board (e.g., Freeman 1948; Cody 1949*).

Development in the north required a better understanding of natural resources. With the proposal for a Mackenzie valley gas pipeline, activities, including plant inventories, increased dramatically in the Northwest Territories, particularly in the vicinity of the Mackenzie River. The Canadian Wildlife Service (now part of Environment Canada) sponsored numerous studies to provide information for landscape planning in connection with protection of wildlife, and Bill was invited to provide botanical information. Between 1964 and 1974, the International Biological Program was a major force. It sought to identify critical natural areas and to apply current methodologies to ecosystem ecology on a global scale. Large advances in knowledge of the north resulted from this program, and Bill contributed extensively. For example, he produced a comprehensive report (Simmons and Cody 1974*) proposing ecological reserves in the Northwest Territories (Plains of Abraham, Brackett Lake, Glacier Lake, and Pilot Lake). The economic as well as strategic benefits of a presence in the north were well understood. Funding to support this development became widely available, and travel in the north suddenly became a lot easier. For example, Bill was able to take advantage of the Polar Continental Shelf Program of Natural Resources Canada, which provided well-organized and efficient transport to remote areas by small airplane and helicopter.

Expeditions to the north

To write books about plants in the north, Bill had to know what was there. The work of other botanists was useful but not enough for a comprehensive text. This meant that Bill had to travel throughout the northern wilderness, enduring severe weather, hordes of biting insects, risks of bear attack, and the dangers inherent in wilderness travel by bush plane and helicopter.

FIGURE 5. Bill Cody and a dog. Photo likely taken on the Keele River in the lower Mackenzie River valley in 1970. Photographer unknown.

Unlike some, however, Bill was a good fit with the north (Figure 5), and he responded well to what Robert Service called the "Law of the Yukon." The federal Department of Agriculture approved and encouraged Bill's travels, and during his frequent periods of absence his devoted wife Lois cared for their family.

Bill began his work in the north in 1948, collecting specimens at Coral Harbour, Southampton Island, at the north end of Hudson Bay. This and additional expeditions up to 1951 were undertaken as part of the study of biting flies and their habitats for the Defence Research Board. His first visit to the continental Northwest Territories was in 1949, when Bill, accompanied by J. B. McCanse, collected around Yellowknife, the Snare River, eastern Great Bear Lake, and Norman Wells. In 1950, accompanied by C. C. Loan, he collected at Fort Smith, where he studied the salt plains a few miles west of town. In 1951, he collected in central Alaska along the Richardson Highway near Delta Junction with T. J. M. Webster. His field books (now part of the DAO archive) for this Alaska trip indicate that he was there to assist in ecological studies of biting flies, especially mosquito breeding habitats, but as usual he collected extensively and acquired a large amount of information not directly related to the insect studies but essential to our understanding of northern botany.

He did not travel north in 1952, but 1953 saw him collecting in Lac La Biche, northern Alberta, and with R. L. Gutteridge in the vicinity of Norman Wells, the Canol Road, and Aklavik in the Northwest Territories. Bill remained in Ottawa in 1954 and did very little fieldwork. In 1955, he was making collections with J. M. Matte in Fort Simpson. These collections were particularly significant, as many were the first reports of species that are now known to be invasive in the region. He was unable to travel north in 1956, but in 1957 he collected with D. H. Ferguson around Reindeer Station

on the east side of the Mackenzie River delta. From 1958 to 1960 he did not travel north, but in 1961 he worked with K. W. Spicer for the federal Department of Agriculture with a soil survey party along the Liard River from the British Columbia border to the junction with the Mackenzie River at Fort Simpson. In 1962, he was not in the north, but in 1963 he was collecting again at Reindeer Station, as well as on the east slope of the Richardson Mountains to try to determine the effects of grazing by introduced reindeer on the local habitats. In 1964, he was not in the north but in 1965 he collected along the Slave River between Fort Smith and Great Slave Lake, including Hay River. It was in 1965 that he and Erling Porsild of the National Museum of Canada (now the Canadian Museum of Nature) began writing *Vascular Plants of Continental Northwest Territories*. In 1966, Bill was again in the southern Northwest Territories.

In 1967, along with K. W. Spicer, he collected in the Mackenzie Mountains with a field party from the Geological Survey of Canada and in the southern part of Yukon along the newly constructed Robert Campbell Highway and Nahanni Range Road. This was his first time collecting in Yukon. Bill was absent from the north in 1968 and 1969. In 1970–1972, he took part in field studies in the Mackenzie Mountains and various other localities in the southern Mackenzie District to assess sites that had been recommended for preservation in the International Biological Program/Conservation of Terrestrial Habitats project. He was on the Keele River in 1970 when he barely escaped a severe flood of his riverside camp (see below). Bill did not go north again until 1980, when he travelled extensively in Yukon collecting throughout southern Yukon from Watson Lake along the Alaska Highway, through Carcross and Tagish, Whitehorse, Kluane Lake, Haines Junction, the Haines Road, the Canol Road, Ross River, Carmacks, then up the Dempster Highway to Inuvik. He then began a reconnaissance in the area, which was then known as "the Northern Yukon National Park study area." Helicopter support was provided by the Polar Continental Shelf Program. This area included the British Mountains and the Yukon North Slope. Sites visited in this first significant Yukon trip included the Clarence Lagoon, Stokes Point, the Firth River, the Malcolm River, Roland Creek, Spring Creek, Empire Mountain, and Komakuk Beach. He continued retracing the Dempster Highway and the Klondike Highway, the Nisling River and on to Haines Junction and throughout the Front Ranges of Kluane National Park, including Kathleen Lake, the Alsek River, the Slims River, and Mount Decoli. He then travelled through Whitehorse again to Ross River via the South Canol Road, back to the Klondike Highway to Dawson City, and once more onto the Dempster in what is now Tombstone Park.

In 1981, he collected in the vicinity of Fort Liard in the Northwest Territories and on the South Canol Road in Yukon. He worked in the Macmillan Pass for several weeks, and for the first time he was invited to cooperate with the Government of Yukon as an expert on the region. It was at this time that he met Catherine Kennedy, who remained a friend and colleague. As well as collecting in southern Yukon in 1982, Bill collected throughout the Richardson Mountains, where, with helicopter support provided by funding from the Polar Continental Shelf Program and with the help of mycologist James H. Ginns, he collected nearly 2500 specimens. In 1983, he once again teamed up with Catherine Kennedy and collected in the southeastern corner of Yukon, including some significant sites near and including Coal River Springs and along the Alaska Highway. In 1984, he returned with J. H. Ginns and, with helicopter support, collected throughout the Ogilvie and Wernecke mountains, in the Dawson City area (including West Dawson), and downstream on the Yukon River to the Alaska border. He once again amassed an amazing number of collections in excess of 2500. It was mainly through the collections of 1980–1984 that he was able to begin compiling his final great botanical work, *Flora of the Yukon Territory*, which was published in 1996.

Although 1984 was his last official scientific expedition to the north, Bill was to make four more family-related trips. Beginning in 1999, he took four of his children, one by one, to see the Yukon by travelling Yukon's southern highways. He took Gordon in 1999 and once again travelled the southwest Yukon before travelling north up the Dempster Highway and assisting Catherine Kennedy with research on Herschel Island. In 2000, with his son David doing most of the driving, he travelled over 4500 km of roads in the central and western part of Yukon from the Alaska border west of Dawson and Beaver Creek to the British Columbia boundary on the Haines Road and Klondike Highway and along most of the Canol Road. They collected a total of over 500 sheets of specimens from 156 locations, making significant collections of introduced species along the roadsides. This was a remarkable distance to cover and a substantial collection — quite an achievement for a three-week trip, sometimes on dangerous roads. In 2001, Bill returned with his daughter Margaret, travelling the highways and byways of central Yukon, again collecting hundreds of plants and travelling over an extensive area and camping in the wilderness (Figure 9). Finally, in 2002, Bill returned for his final visit to southern Yukon with his son Douglas. Not surprisingly, this trip also resulted in a good number of plant collections.

A flood on the Keele River

Wilderness travel is dangerous. Help can be thousands of miles away. While knowledge, experience, and common sense provide some protection, events often cannot be predicted or controlled. So it was in the log cabin (Figures 6 and 7) beside the Keele River in the lower Mackenzie River valley on 20 July 1970.

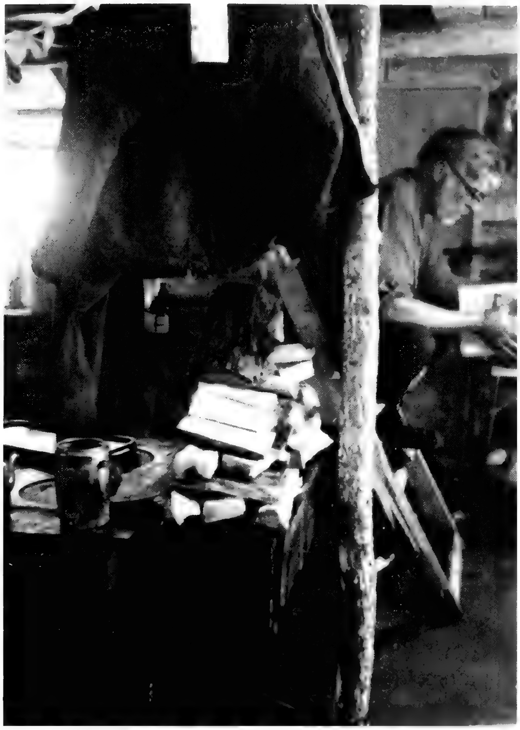


FIGURE 6. Bill sitting reading on the ladder to the attic. A bottle of Fisher alcohol can be seen under the coat, and split wood is piled on the edge of the wood stove. This was rough accommodation, but much of Bill's time in the north was spent in tents drying plant specimens in presses over an open fire. Keele River, Northwest Territories, 1970. Photographer unknown.

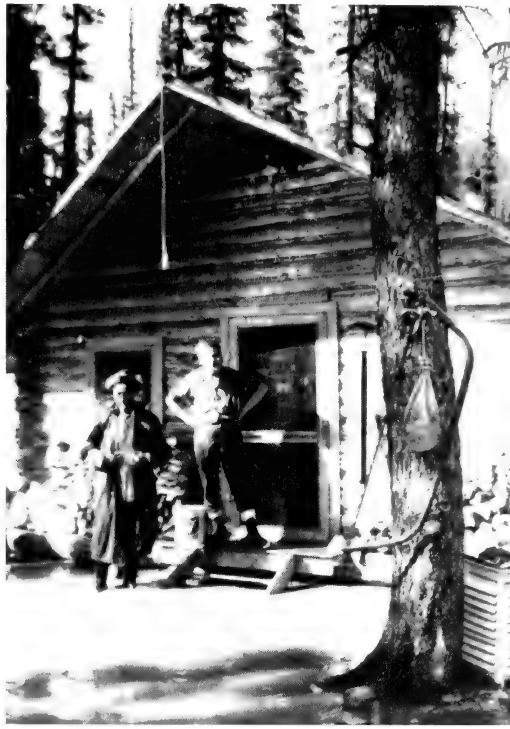


FIGURE 7. Bill Cody (right) and Dene Gabe (left, standing in floodwater) at the log cabin as floodwaters rose to the front door. The water eventually rose to at least the level of Bill's waist. Keele River, Northwest Territories, 1970. Photographer unknown.

Nine people occupied a log cabin and canvas wall tents on the forested shore of the Keele River. The group included skilled Mountain Dene, Uncle Gabe (Gabriel Etchinelle, who had spent much time there); a bush plane pilot and jet boat driver named Perry Linton; "Wild Bill Cody and his plant presses"; John Day, who was a soil specialist; Norman Simmons (Simmons and Cody 1994*), and Harry Armbruster of the Canadian Wildlife Service, who were studying Dall's sheep and caribou; and Hilah Simmons with seven-year-old Debby and five-year-old David.

The usual preparations for the day's work — collecting plant and soil specimens, tree measurements, aerial sheep surveys — suddenly gave way to surprise as heavy rains began. Within minutes, the river began to flow faster, rose and turned brown. A few minutes later whole trees ripped away from the bank and were carried downstream in the current. There was no time to waste. The boat was secured and two of the men set off to the airstrip a mile downriver to secure the plane. They were not able to reach it because the woodland camp was now surrounded by rising water channels, so they set out again in an inflatable boat. At the camp, fuel was moved to the highest ground, the dock was moved up the bank, the tents were brought into the cabin, and material was suspended from trees. The water began to come into the cabin. First bags and then blankets were moved to the upper bunks. Water was soon knee high in the cabin. The kids, dry clothes, food, and blankets were moved to the attic. The malamutes, with no place to go, were barely recovered through an open window as the current rushed by.

Amidst shouts of panic drowned out by the sound of rushing water, a discussion commenced. Should they stay in the cabin or get into the boat? Where were the others who had gone to the airstrip? The brown river roared against the cabin as waves carried debris past. Nearby trees had gone. It was too late to get in the boat; both boat and dock were gone. Water rose over the table and stove, where the dogs perched, looking for a higher shelf. Nothing was said. Hours passed with nothing but the sound of rushing water, pelting rain,

and walls groaning against the sheer pressure of the water. Would they be swept away? Now it was just a matter of waiting. How much more could the water rise before the lower logs became buoyant and rose, making the cabin fall? The cabin creaked and groaned, and all lay snug and silent for a long time.

Gradually the rains stopped. One day became another, and the water went down. Piles of wet sand, puddles, and debris surrounded the camp, and river channels were still high and fast. A radio antenna was affixed to a tree, and a mayday signal was sent to Fort Liard. The helicopter finally arrived and was dispatched to the airfield. The plane rescue was unsuccessful (the plane had disappeared), but the two rescuers were on a tiny platform built in the nearby trees, where they had been for almost 24 hours. Everyone made it. The jet boat was extricated from the treetops and pushed back to the river across the snye (side channel) before the water level fully subsided. A new base camp had to be set up until the runway was drained and cleared. Yes, Bill's plant specimens survived, dry and safe in the attic.

The preceding story is as told by Bill, but it also appeared on pages 24 and 25 of the January 2001 issue of a local newspaper, the *Mackenzie Valley Viewer*.

Post-expedition period, 1985–2008

This period of compiling information, identifying thousands of specimens, and preparing current identification keys required special skills. These skills are quite different from those needed for northern travel. Hard and diligent work was essential, but Bill's interest in working with people also played a major role. This period was probably just as important to Bill's achievement as the expeditions in the north. It included major follow-up research contributions and, because he enlisted the help of others, knowledge of and responsibility for information on northern flora were greatly expanded during this period.

While Bill's early work in the north often utilized material collected by others, there were few, other than Alf Erling Porsild (see Soper and Cody 1978a,b*), with a deep interest in northern plants. That changed after the Porsild and Cody (1980*) flora, which enabled more people to be involved. Most major contributions involve more than one person, and Bill's work was no exception. He had help from a number of legendary northern botanists, including G. W. Argus, B. A. Bennett, P. Caswell, Catherine Kennedy, K. L. MacInnes, K. L. Reading, R. Rosie, G. W. Scotter, and S. C. Zoltai. Other people also helped, including his daughter Leslie in particular, who typed or input his manuscripts. Bill was a very pleasant and dependable person to work with and there can be little doubt that this helped him to achieve as much as he did.

The essence of Bill's achievement in the north

For many northern species, there were only a few records half a century ago. Bill dramatically changed that by finding many hundreds of plants in new areas and noting their habitats. Our knowledge of the occurrence and ecology of northern plants expanded enormously by 2008. Of course, this vast increase in knowledge is also reflected in the number of taxa known. For example, in 1943 Porsild reported 731 taxa (species and infrataxa) from the Northwest Territories. The flora of the Northwest Territories is now known to contain over 1254 species alone (not including infrataxa: Catling et al. 2008), roughly double the number reported by Porsild, and much of this is attributable to Bill's work. The same is true for Yukon, where Bill added 208 taxa. Although our knowledge of the northern flora may still not be entirely satisfactory, it is vastly improved over what it was.

Since Bill always wanted to be complete in his botanical documentation, he searched for and collected introduced plants. His work in documenting invasive plants provided a baseline for evaluating their spread. Many of the earliest reports of introduced and naturalized species in the Mackenzie River valley are based on Bill's early collections. He produced the first two focused and comprehensive articles on invasive plants in the north, featuring Wood Buffalo National Park (Wein et al. 1992*) and the Norman Wells pipeline (Cody et al. 2000b*). As well as his work in Wood Buffalo National Park (which helped to provide a basis for management of natural resources), Bill published on the flora of other northern protected areas, including Nahanni National Park Reserve (Scotter and Cody 1974*; Cody et al. 1979*), Bylot Island (part of Sirmilik National Park, Cody et al. 1984b*), and Bathurst Inlet (Cody 1954a*; Cody et al. 1984a*).

Most of Bill's collections, actually 75%, were the result of his 17 expeditions to the north, with perhaps a few thousand more from Yukon than from the Northwest Territories and Nunavut. Throughout the period and subsequently, it is estimated that he processed as many as 20 000 specimens collected by others; over 80% of these were from north of the 60th parallel. Always happy to answer questions, he responded to many hundreds of requests for information and identifications each year. Bill made his botanical knowledge of the north available in two books and 71 publications, most of them peer-reviewed.

Bill Cody's work in the north is essential, not only as a basis for the protection of plant biodiversity and for the establishment of protected areas, but also for biological research and ongoing work relating to ecology, forestry, sustainable resource management, and wildlife management. The importance of his work in the north went sometimes beyond that area and covers phytogeographical information relevant to the whole of Canada. The distribution maps in Porsild and Cody's *Vascular Plants of the Continental Northwest Territories* are a good example. As they covered the whole Canada and part of adjacent United States, they become very useful information on the range of many plant species as the only North American maps available before the Flora of North America project. It is

no surprise that northern plants are named after him and that he received major awards for his northern research (see below).

The south

Ferns and fern allies

Bill's largest area of contributions outside his work on the north was in the taxonomy and geography of ferns and fern allies. In this area Bill produced 2 books, 20 journal articles (see Appendix 1: Cody 1955*, 1956b*, 1961c*, 1963c*, 1968*, 1969*; Mulligan and Cody 1969*; Mulligan et al. 1972a*; Cody and Crompton 1975*; Cody and Lafontaine 1975*; Cody et al. 1977*; Mulligan and Cody 1979*; Cody and Wagner 1981*; Cody and Mulligan 1982*; Cody 1983a*; Cody and Britton 1984*; Britton et al. 1985*; Cody and Britton 1985*; Cody and Schueler 1988*; Cody and Britton 1989*; Lichvar and Cody 1994*; Cody 2001*) and 3 encyclopedia contributions (see Appendix 2: Cody 1985d,e,f**). The articles included taxonomic clarifications, such as the name of *Polystichum acrostichoides* × *lonchitis* (Cody 1968*); newly discovered taxa, such as *Adiantum pedatum* ssp. *calderi* (Cody 1983a*); reviews of the biology of economically important species, such as *Pteridium aquilinum* (Cody and Crompton 1975*), *Dennstaedtia punctilobula* (Cody et al. 1977*), and *Equisetum arvense* (Cody and Wagner 1981*); and significant range extensions, such as *Polystichum lemmonii* in British Columbia (Cody and Britton 1984*) and *Cystopteris protrusa* in Ontario (Britton et al. 1985*).

Despite its regional nature, Bill's *Ferns of the Ottawa District* (Cody 1956b*, revised 1978a*) was a very valuable field guide that could be used over an extensive area of the northeast by both naturalists and professional biologists (Desmarais 1957; Britton 1979). It included photographs and keys that facilitated identification. A remarkable number of botanists have used this book to learn about ferns (in 1956, it was only $1.00). For some additional information on this book, see Britton (1979).

Ferns and fern allies of Canada (Cody and Britton 1989*) included a large amount of information, and it brought Bill's earlier work on ferns together. Bill was bogged down in 1983 when the book was scheduled for publication. It was a little outdated because by that time he had been encouraged to turn his attention increasingly to the north. Local fern specialist Dan Brunton had the brilliant idea of inviting another Canadian expert, Don Britton at the University of Guelph (Catling 1991; Brunton 2003), to help finish the job. That made all the difference. Although the content was good (but a little skimpy on discussion of hybrids), the production was poor (binding, layout, maps, etc.) and when published in 1989, it still was obviously an update of the 1983 (or older text) with pre- and post 1983 lists of references and other addenda. These things detracted from its excellent content. One of the better reviews was that of Martin (1990). Although this book was not as well received as Bill's other books, it was considered a very valuable contribution by reviewers (e.g., Barrington 1990) and it did definitely bring knowledge of Canada's fern flora to a much higher level. Considering that Bill was not afforded the same amount of time as other scientists to write due to his extensive curatorial responsibilities, it is a wonder that he was able to complete this work at all.

Phytogeography and floristics

As well as studying and documenting plant distribution in the north, Bill wrote several articles documenting important patterns of plant distribution in southern Ontario, including occurrences of boreal species (Cody 1962b*), a detailed study of plant geography in St. Lawrence Islands National Park (Cody 1975b*), an article relating island size to number of species present in the St. Lawrence islands (McNeill and Cody 1978*), and a detailed review of the northern limits of plants in eastern Ontario that also developed from his research in the St. Lawrence islands (Cody 1982*). The last paper provided very useful distribution maps that were instrumental in updating the knowledge of the range of the rare plants in eastern Ontario, as well as western and southern Quebec.

Bill's contribution to plant distribution, new records, and range extensions included both native and introduced plants for various parts of Canada. Some of them consider North America, Canada, or large areas as a whole (Cody 1953b*, 1954d*; Cody and Talbot 1973*; Cody 1975a*, 1978c*), while others are of provincial or of local importance: Prince Edward Island (Cody and MacLaren 1976*); New Brunswick (Cody and Munro 1980*); Ontario and Quebec, including James Bay (Cody 1954c*) and the Ottawa District (Cody 1957*, 1967a*); Ontario (Cody 1952*, 1962b*, 1970*; Cody and Boivin 1973*; Cody and Putman 1986*; Staniforth et al. 2002*); Manitoba (Cody and Krivda 1974*; Cody 1980*; Cody and Saquet 1984*); Saskatchewan (Cody 1973*, 1988a*); Alberta (Cody and Shaw 1973*; Cody et al. 1974*; Cody and Scotter 1990*); and British Columbia (Cody 1967b*).

The native genera considered here are remarkably various and indicate Bill's broad knowledge of Canadian vascular plants, including *Carex* (Cody and Krivda 1974*), *Cypripedium* (Cody 1973*), *Draba* (Cody 1957*), *Elymus* (Cody 1967b*), *Listera* (Cody and Munro 1980*), *Loiseleuria* (Cody et al. 1974*), *Lythrum* (Cody 1978c*), *Monotropa* (Cody and Saquet 1984*), *Phyllodoce* (Cody 1953b*), *Pinguicula* (Cody 1962b*), *Prunus* (Cody and Shaw 1973*), *Rorippa* (Mulligan and Cody 1995*), *Salicornia* (Cody 1954c*), *Sarracenia* (Cody and Talbot 1973*), *Scheuchzeria* (Cody 1975a*), *Tillaea* (Cody 1954d*), and *Wolffia* (Cody 1980*). As reported above, Bill was always interested in new records of introduced plants, whether adventive, escaped from cultivation, or new weeds, and his papers would present them according to their national or regional impact. The main genera include

the following: *Ceratocephalus* (Cody 1988a*), *Chrysopsis* (Cody 1952*), *Crepis* (Cody and Putman 1986*), *Echinacea* (Cody and Boivin 1973*), *Geranium* (Cody and Scotter 1990*), *Iris* (Cody 1961b*), *Lychnis* (Cody and Frankton 1971*), *Sedum* (Cody 1967a*), *Sorbaria* (Cody 1962a*), and various others (Cody and MacLaren 1976*).

Botanical inventories of parks

In the 1970s, the Department of Agriculture (which was where the botanists and entomologists in the federal government were located) assisted with biological inventories of Canadian parks (Catling and Cody 1987*). Bill was responsible for inventories of the vascular plants of St. Lawrence Islands National Park (Cody 1975b*, 1978b*). For this project he contributed, with technician Derek Munro, to the small herbarium of the park (Boivin 1980). Bill was also responsible for the inventory of Riding Mountain National Park (Cody 1988b*). The latter was published as an identification guide. It included 88 plant families, 300 genera, 669 species, and 2 hybrids, with keys that included brief descriptions and line drawings of about half of the flora (Cayouette 1989). All this resulted from surveys done in 1979 and 1983, with the help of technician Walter Wojtas, and examination of previous records in various herbaria. The book contains information such as relationships between tree species and soil and physiographical aspects, an outline of the main plant population ranges, and the major forest and ecological groups of the park. It became a very useful guide to the vascular plant biodiversity in the park and has been extensively used in park planning. Unfortunately, the French version, which could have been very useful for francophones in eastern as well as western Canada, would have benefited from the knowledge and editorship of a francophone botanist. Learning of the problems with the French translation afterward, Bill considered himself the author of the English version but not of the French (Cayouette 1989).

Bill was also instrumental in the botanical exploration of another Canadian park, Kouchibouguac National Park in New Brunswick. He supervised the fieldwork and report of technician Derek Munro, and he helped to produce a list of all the identifications (Munro 1979). One paper on *Listera* in New Brunswick came out of this important inventory (Cody and Munro 1980*). Several other park inventories that Bill did were of the northern parks, including Nahanni National Park Reserve, Bylot Island (part of Sirmilik National Park), and Bathurst Inlet (see above).

Bill and The Ottawa Field-Naturalists' Club

Bill made a huge contribution to the biology/conservation organization, The Ottawa Field-Naturalists' Club (OFNC) (Cook 1987); see also Brunton (2004) for a fascinating history of the OFNC. Bill joined the OFNC (founded 1879) when he arrived in Ottawa in 1946. He was appointed assistant treasurer in 1947 and was elected to Council in 1948 and served continuously until 2007.

He was appointed to the newly created post of business manager in 1948. One of his first duties was to organize the extensive holdings of issues of the *Canadian Field-Naturalist* (formerly the *Ottawa Naturalist,* 1887–1919, and the *Transactions of the Ottawa Field-Naturalists' Club,* 1879–1886) and to advertise their availability for sale as sets and single numbers to help support the publication costs of subsequent issues. As well, he assumed responsibility for reprint orders and mailing lists (all of which had been handled by the editor in addition to correspondence with authors, editing, proofing galley, and preparing page proof). With Bernard Boivin (Cody and Boivin 1954*), detective work allowed the mailing dates (important for dating original taxa descriptions) to be compiled for previous issues. Bill reduced his non-journal responsibilities in the OFNC in 1968, when the increasing size of the journal made it necessary to make its business manager a separate position.

Bill was instrumental in the financial survival and growth of the journal through several lean years following World War II and in its growing importance in publishing original contributions to northern North American natural history (Cook 1987). His tenure spanned the terms of five very different editors (Harold Senn till 1955), Bob Hamilton (1956–1961), Francis Cook (1962–1966), Ted Mosquin (1967–1972), Lorraine Smith (1972–1981), and Francis Cook again (1981 to 2010), during which time the journal grew from 150 pages a year (1946) to 400–800 pages. Each editor brought individual idiosyncrasies and innovations and progressive editorial improvements that changed the format and emphasis of the journal. Yet its basics remained the same — a peer-reviewed journal of original research and observations that is interesting and readable for both naturalists and scientists, specialists and generalists. This stability was helped in large measure by Bill's continuous presence (Cook 2010). He also made a fundamental contribution to the journal's independent status, supported by journal subscriptions, club memberships, and page charges to authors. This was supplemented externally only by a small annual postage grant from the federal Department of Canadian Heritage. He continued to serve as business manager of *The Canadian Field-Naturalist* and actively helped maintain it as one of Canada's premier biodiversity and field biology journals until 2007, when he became honorary business manager. That is 59 years! As much as anything else, Bill was an Ottawa Field-Naturalist, like Frank Pope, James Fletcher, Percy Taverner, Sheila Thomson, Joyce Reddoch and all the rest, linked by the common thread of natural values (so aptly put by Brunton (2004), who himself belongs in the same group).

Cook (2010) has remarked that every visit he made to the Saunders Building on the Central Experimental Farm was marked by the friendly and cordial atmos-

phere among both scientists and support staff, due in no small part, one suspects, to the tone set by the always cheerful Bill. Throughout his years on OFNC Council, Bill hardly ever missed a meeting, and the Council had to wait for a rare absence in 1979 to elect him (by surprise to avoid his protest) as an honorary member for his, even at that time, long service (Anonymous 1980). For many years, the OFNC Publications Committee meetings, which Bill also never missed, were held over bag lunches at noon at the Saunders Building, with Bill invariably greeting each committee member with a choice of tea or instant coffee.

For all business manager correspondence and invoices, Bill was never weaned from his trusted manual typewriter dating from the 1940s (Cook 2010). Failed efforts were made, including moving a computer into his office for an extended period; it was ignored. In contrast, when others at Agriculture and Agri-Food Canada began having their manuscripts entered into computers, he joined in by having his processed by staff or daughter Leslie. In the early 1980s, he was among the first to submit a disc to *The Canadian Field-Naturalist* along with the traditional hard copy of the manuscript. The journal's printing company at the time first regarded these discs as more bother than help to the typesetters, but within a couple of years would complain if a manuscript came without a disc. This rapid change was aided by relentless championing from the sometimes otherwise Luddite-seeming Bill. He had quickly realized that author-produced discs, though needing editorial additions, would save significant typesetting time and allow him to negotiate a reduction of costs with the printer, and he was unhesitatingly in favour of promoting this. It is likely that today, with the steadily rising postal costs, Bill would have even supported the journal's current move to computer-generated invoices and e-mailed dispatch of galley and reprint order forms to authors (Cook 2010).

Although it is Bill's service to The OFNC that stands out, he helped a number of other organizations. For example, in 1965 he served as the first treasurer and was a founding member of the Canadian Botanical Association, which has became an influential national society (Taylor 1969). In the late 1990s, he joined the Flora of North America project, providing extensive support and applying his extensive knowledge of phytogeography as a regional reviewer.

Recognition and Awards

Species named in his honour

Four plants have been named in Bill's honour:

Arabis codyi Mulligan (Rhodora 97: 151. 1995) with a type locality west of Kluane Lake.

Ranunculus codyanus Boivin (Canadian Field-Naturalist 65: 3-4. 1951) with type locality at Coral Harbour, Southampton Island.

Puccinia codyi Savile (Fungi Canadenses Number. 46. 2 pages (1974) with type locality in the Mackenzie Mountains, Northwest Territories..

Saxifraga codyana Zhmylev (Bulletin of Moscow Society of Naturalists Biological Series 97(1): 95-96. 1992) collected at 69°13'N, 139°35'W, in the Buckland Hills, Firth River drainage, Ivvavik National Park (then known as Northern Yukon National Park Reserve). This taxon was later treated as *Saxifraga bronchialis* ssp. *codyana.*

1996 – Richards Education Award

On Thursday, 7 November 1996, at the 65th anniversary dinner of the Federation of Ontario Naturalists, The Ottawa Field-Naturalists' Club received the Richards Education Award. The award recognized the very special contribution to natural history education made by *The Canadian Field-Naturalist* (Pope 1997). Although the award was given to The OFNC, it was the relentlessly effective team of the journal business manager, Bill Cody, and its editor at the time, Francis Cook and his predecessors, backed up by a Publications Committee chaired effectively by Ron Bedford, that was largely responsible (Figure 8). Bill's work for The CFN was also highlighted by the Queen's Golden Jubilee Commemorative Medal (see page 84).

The Canadian Field-Naturalist began with the *Transactions* in 1880, which became *The Ottawa Naturalist* in 1887, which in turn became *The Canadian Field-Naturalist* in 1919. For more on CFN history and its significant reconfiguration in 1970 to a stronger conservation orientation, see Brunton (2004). *The Canadian Field-Naturalist* may be one of the biggest success stories of the OFNC. It has become a very popular, influential and respected journal of science and natural history and one of the leading field biology journals in Canada. It is used by naturalists and professional biologists alike. It has strongly influenced conservation and is the major source of education in field biology in Canada. The OFNC is in good company as a recipient of this award. Among the others who have received it are Dan Strickland and Ron Tozer for their interpretation programs in Algonquin Park; these programs not only educated many thousands but also contributed to the development of the largest group of expert and influential field biologists in Canada.

1997 – Distinguished Technical Communications Award

The Society for Technical Communications found Bill's book, *Flora of the Yukon Territory,* to be a masterpiece of communication. Indeed, the design was in some respects a little ahead of its time, with illustrations, distributions maps, and brief text providing a wealth of information in a very easy to use format. Bill worked with designer and artist Marcel Jomphe to achieve this excellent example of technical communication. The reviews were very favourable. In the journal *Taxon* (International Association for Plant Taxonomy),

the review of the book starts, "Doubleplusgood! Wow! Most impressive! Lavishly done!... are some instant reactions ..." (Schmid 1997). David Murray of the University of Alaska had used his copy so much that it was almost destroyed by the time he reviewed it (Murray 1997). See also Catling (1997).

1997 – Lawson Medal

In 1997, Bill received the most prestigious award given by the Canadian Botanical Association (Chinnappa 1997). The Lawson Medal provides a collective formal expression of admiration and respect for excellence from the botanical science community across the country and internationally. Bill received this award for his work on the distribution, ecology, and classification of the plants of the Yukon Territory, gathered together in a monumental volume of 643 pages published by NRC Research Press. This work, *Flora of the Yukon Territory* (Cody 1996b*; 2nd edition, Cody 2000a*), is essential, not only as a basis for the protection of plant biodiversity but also for biological research and ongoing work relating to forestry, sustainable resource management, and wildlife management in the north. It included much new information and many discoveries as well as a thorough compilation and a novel analysis. It is a masterpiece of botanical science. In addition to this award for scientific content, it received a communication award (see above).

1998 – Special OFNC Service Award

On 18 September 1998, a special reception was organized to recognize Bill's 50 years of service to The Ottawa Field-Naturalists' Club. He had already been made an honorary member for 33 years of service in 1979 (the same year as legendary Canadian field biologist C. H. D. Clarke was made an honorary member) (Anonymous 1980). Bill's 40-year landmark had also been recognized in 1987 (Cook 1987). At the reception in 1998, past presidents Bill Gummer and Frank Pope made outstanding presentations, actually some of the best presentations ever witnessed at an event of this kind, with CFN editor Francis Cook adding additional remarks. Bill received an exquisite carving of a Black-capped Chickadee from Ellaine Dickson and a plaque with a drawing of a Walking Fern and an inscription: "This plaque is presented to William J. Cody by The Ottawa Field-Naturalists' Club in recognition of 50 years of outstanding service as Council Member and Business Manager of *The Canadian Field-Naturalist* (1948-1998), September 18, 1998." For more information on this award and the event, see Darbyshire and Taylor (1999) and Darbyshire (1998).

2002 – Queen's Golden Jubilee Commemorative Medal

In November 2002, Bill received a Queen's Golden Jubilee Commemorative Medal. These medals marked the 50th anniversary of the accession of Queen Elizabeth II to the throne. They were awarded to a limited number of people who had made a significant contribution to Canada, in this case, "especially for his work on *The Canadian Field-Naturalist,* Canada's foremost scientific journal for field biology." Bill has served as the business manager and reviewer for this journal for more than 50 years, and his influence on its development, improvement and content is beyond question. See also Richards Education Award, above.

FIGURE 8. Richards Natural History Award trophy. Sitting in front are Bill Cody (left, *Canadian Field-Naturalist* business manager) and Francis Cook (right, *Canadian Field-Naturalist* editor). Standing behind are Dave Moore (left, OFNC president) and Ron Bedford (right, OFNC Publications Committee chair).

2006 – Yukon Biodiversity Awareness Award

In 2006, Bill received the Yukon Biodiversity Awareness Award in recognition of his enormous contribution to the understanding of the Yukon flora. Bill's 643-page textbook, *Flora of the Yukon Territory,* was first published in 1996. It included current information on status, distribution, ecology, classification, and identification. A second, updated edition of the book was published by NRC Research Press in 2000. Bill was also author of 15 scientific papers on the flora of Yukon. Botanical work in Yukon was a large part of Bill's northern botanical legacy (Bennett and Catling 2009 and see above). Always willing to help, he identified a thousand plants from Yukon every year. It is therefore no surprise that Bill was recognized for his outstanding service with the Yukon Biodiversity Awareness Award. The award honours those who have made major contributions to educating people about biodiversity and its importance. The plaque that Bill received included a photo of one of Yukon's rarest plants, McBride's Phacelia (*Phacelia mollis*), which is a Beringian endemic (confined to the unglaciated area of Alaska and Yukon). For more information, see Anonymous (2004a,b).

2006 – Honorary Degree from McMaster University

During the 1940s, a number of renowned Canadian botanists received their degrees from McMaster University. All but one of these earned a Ph.D. William James (Bill) Cody was the exception. It was a B.A. that he received in 1946. He eventually became a scientist, and many people addressed him respectfully as "Dr. Cody," thinking that he had the degree since most scientists did. It was 38 years later that Bill received an honorary degree from his alma mater, McMaster University in Hamilton. The university was sufficiently impressed with his outstanding scientific contributions to Canadian botany that it made him Dr. Bill Cody *honoris causa* (for the sake of honour) (Anonymous 2007, 2008).

Just remembering Bill

The best short description of Bill may well be the 50 words that his family prepared for a memoriam. Much that is on that list has already been said here, but we have not mentioned that he was also an avid bridge player and an excellent square dancer. He liked to go for walks, but his children were always waiting for him to catch up because he had to examine every plant along the way. Bill will be remembered in different ways by different people. His smile (Figure 9) will be remembered by all. For us, he was remarkable for his achievements as a biologist and his value as a co-worker. For everyone he was a teacher by example, with optimism, modesty, dedication, and generosity. He will always be a cherished memory.

FIGURE 9. Bill Cody with his characteristic smile in 2001 at Lapie River canyon (near Ross River), Yukon. Photo by Margaret Cody during her trip to Yukon with Bill.

Acknowledgments

Help from Bill's family is much appreciated, particularly from Margaret Cody, who coordinated with the family to provide information, from Leslie Cody-Durocher, who helped with Bill's publications and provided other valuable information, and from David, who provided detailed information on fieldwork with Bill in 2000. Bill himself also contributed much to this. He enjoyed talking about the past, but only when questioned, at a tea break (he hated coffee). Many colleagues also provided information about Bill's achievements. We also very much appreciate the editorial help of Liz Morton and useful comments of Ron Bedford, Frank Pope, Joyce Reddoch and Karen McLachlan Hamilton.

Literature Cited

Anderson, J. P. 1959. Flora of Alaska and adjacent parts of Canada. Iowa State University Press, Ames, Iowa. 543 pages.

Anonymous. 1980. New honorary members of the Ottawa Field-Naturalists' Club. Canadian Field-Naturalist 94(3): 345-346.

Anonymous. 2003. A Golden Jubilee Medal to Bill Cody. Canadian Botanical Association Bulletin 36(1): 1.

Anonymous. 2004a. Bill Cody receives Yukon Biodiversity Awareness Award. Canadian Field-Naturalist 120(2): 258-259.

Anonymous. 2004b. Yukon Biodiversity Awareness Award 2006 – W. J. "Bill" Cody. Botanical Electronic News 363: 1-2.

Anonymous. 2007. Honorary doctorate for William J. (Bill) Cody. Botanical Electronic News 380: 1.

Anonymous. 2008. Mr. Bill Cody, honorary doctorate of science, June 2, 2007. Trail & Landscape 42(1): 4-5.

Barrington, D. S. 1990. Book Review, *Ferns and fern allies of Canada*. Rhodora 92(871): 207-208.

Benner, J. 2005. Bill Cody – a passion for the north. Friends of the Central Experimental Farm. Winter 2005. 9.

Bennett, B. A., and **P. M. Catling**. 2009. William (Bill) J. Cody: a legacy of contributions to northern Canadian botany. Botanical Electronic News (E-journal) 410: 1-5. http://www.ou.edu/cas/botany-micro/ben/ben410.html and: http://bomi.ou.edu/ben/410/bill-cody-bibliography.pdf.

Boivin, B. 1980. Survey of Canadian herbaria. Provancheria 10: 1-187.

Britton, D. M. 1979. Review of *Ferns of the Ottawa District*. Canadian Field-Naturalist 93(3): 345.

Brunton, D. F. 2003. Donald M. Britton at the occasion of his 80th birthday on March 6th, 2003. Botanical Electronic News 304-305: 1-2.

Brunton, D. F. 2004. Origins and history of the Ottawa Field-Naturalists' Club. Canadian Field-Naturalist 118(1): 1-38.

Catling, P. M. 1991. 1991 Lawson Medals. Canadian Botanical Association Bulletin 24(4): 64-67.

Catling, P. M. 1997. Review of *Flora of the Yukon Territory*. Canadian Botanical Association Bulletin 30(2): 27-30.

Catling, P. M. 2003. Three remarkable volunteers at the DAO vascular plant herbarium, Agriculture and Agri-Food Canada. Botanical Electronic News 310: 3-4. http://www.ou.edu/cas/botany-micro/ben/ben310.html

Catling, P. M. 2009. Passing of Bill Cody. AAFC News. 1 page.

Catling, P. M., and **P. T. Dang.** 1992. Collections overview – an overview of their perception, needs and significance. Pages 27-38 + figures *in* Proceedings of the Workshop on Systematics. *Edited by* P. Marriage. University of Ottawa, 16-17 June 1992. Agriculture Canada, Research Branch Publication A52-69/1992E.

Catling, P. M., G. Mitrow, and **B. A. Bennett.** 2008. A compilation of additions to the flora of the continental portions of Northwest Territories and Nunavut – number 2. Botanical Electronic News (E-journal) 400 (October 2008): 2-12.

Catling, P. M., G. Mitrow, and **J. Cayouette**. 2009a. William James (Bill) Cody (1922-2009). Canadian Botanical Association Bulletin 42(2): 37-38. Also Flora of North America Newsletter 23(1): 10-11.

Catling, P. M., G. Mitrow, and **J. Cayouette.** 2009b. The Vascular Plant Herbarium. About the Vascular Plant Herbarium, History of the Vascular Plant Herbarium, How the Vascular Plant Herbarium is Organized, How the Vascular Plant Herbarium is Used, The Importance of the Vascular Plant Herbarium, Catalogue of Type Specimens, The National Vascular Plant Identification Service, Specimen Exchange Program, Collection Databases, Collecting Specimens, References for Identification, Depositing a Cultivar Voucher, Requesting a Loan, Requesting a Journal Reprint, Guidelines for Visitors http://www4.agr.gc.ca/AAFC-AAC/display-afficher.do?id=1251393521021&lang=eng, Agriculture and Agri-Food Canada/Agriculture et Agroalimentaire Canada, Ottawa, Ontario. (Available online)

Cayouette, J. 1989. Review of *Flore du parc national du mont Riding, Manitoba*. Le Naturaliste canadien 116: 283-284.

Cayouette, J. 2009. Bill Cody (1922-2009), un maître de la flore nordique. FloraQuebeca 14(2): 13-14.

Chinnappa, C. C. 1997. Awards at Montreal. Canadian Botanical Association Bulletin 30(4): 58-59.

Cody, L. S. 1954. The Cody family in America. 1698. Cody Publications Inc., Kissimmee, Florida. 257 pages.

Cook, F. 1987. A continuing salute: William James Cody: Managing the Canadian Field-Naturalist. Canadian Field-Naturalist 101(2): 159-160.

Cook, F. R. 2010. On missing Bill: Recollections from 5 decades. Trail & Landscape 44(2): 58-61.

Darbyshire, S. 1998. Yet another milestone for William James Cody. Canadian Field-Naturalist 112(4): 719-720.

Darbyshire, S., and **K. Taylor**. 1999. Yet another milestone for William James Cody. Trail & Landscape 33(1): 3-5.

Desmarais, Y. 1957. Revue des livres. W. J. Cody – *Ferns of the Ottawa district*. Le Naturaliste canadien 84(1): 35.

Freeman, T. N. 1948. Entomological research in northern Canada progress report 1948, Part 1, The northern insect survey. Defence Research Board. Report No. D.R. 18. 36 pages + appendices.

Freeman, T. N. 1954. Present trends and future needs of entomological research in northern Canada. Part 1. The northern insect survey. Arctic 7: 275-279.

Freeman, T. N. 1959. The Canadian Northern Insect Survey 1947-57. The Polar Record 9(61): 299-307.

Gillett, J. M. 1980. Transactions of the Ottawa Field-Naturalists' Club and the Ottawa Naturalist Index. Ottawa Field-Naturalists' Club Special Publication No. 2. 195 pages.

Hooker, W. J. 1829-1940. Flora Boreali-Americana. London.

McLachan Hamilton, K. 2010. William (Bill) James Cody. Trail & Landscape 44(1): 4-6.

Hultén, E. 1941-1950. Flora of Alaska and Yukon, 1–10. Lunds Universitets Arsskrift N. F., Aud. 2. Vols. 37-46. 1902 pages.

Hultén, E. 1968. Flora of Alaska and Neighboring Territories – A Manual of the Vascular Plants. Stanford University Press, Stanford, California. 1008 pages.

Martin, V. 1990. Review. *Ferns and fern allies of Canada*. Seasons (Federation of Ontario Naturalists) (Winter 1990): 43.

Moore, R. J., and **W. F. Grant**. 1965. Lulu Odell Gaiser, 1896-1965. Genome 7(3): 361-362.

Munro, D. 1979. A floristic study of Kouchibouguac National Park; a survey of vascular herbs, shrubs, and trees. Report, Biosystematics Research Institute, Ottawa. 213 pages + appendices.

Murray, D. F. 1997. Review of *Flora of the Yukon Territory*. Systematic Botany 22: 596-597.

Polunin, N. 1940. Botany of the Canadian eastern Arctic. Part 1. Pteridophyta and Spermatophyta. National Museum of Canada Bulletin 92: 1-408.

Pope, F. 1997. Richards Natural History Education Award. Trail & Landscape 31(2): 41-42.

Pope, F. 2010. Bill Cody and the Ottawa Field-Naturalists. Some reflections upon the man I knew. Trail & Landscape 44(1): 6-8.

Porsild, A. E. 1943. Materials for a flora of the continental Northwest Territories of Canada. Sargentia 4: 1-79.

Porsild, A. E. 1945. Alpine flora of the east slope of Mackenzie Mountains, Northwest Territories. National Museum of Canada Bulletin 101: 1-35.

Pringle, J. S. 1995. The history of the exploration of the vascular flora of Canada. Canadian Field-Naturalist 109: 291-356.

Raup, H. M. 1947. The botany of southwestern Mackenzie. Sargentia 6: 1-262.

Schmid, R. 1997. Review of *Flora of the Yukon Territory*. Taxon 46: 150.

Taylor, R. L. 1969. Founding of CBA - ABC — a review. Canadian Botanical Association Bulletin 2(2): 5, 8.

Walsh, R. J., and **M. S. Salsbury.** 1928. The making of Buffalo Bill. The Bobbs-Merrill Company (reprinted 1978). Cody Publications Inc., Kissimmee, Florida. 391 pages.

Appendix 1. W. J. Cody – Referred publications, books and reports, in chronological order

For a list of Bill's book reviews, encyclopedia contributions, and other miscellaneous publications, see Appendix 2. All of Bill's northern work is included here but, for a complete list of his publications dealing with northern Canada alone (and separated for the territories), as well as a general outline of Bill's northern work, see Bennett and Catling (2009). Reports are preceded by an asterisk.

*Cody, W. J.** 1949. Report on the field work at Coral Harbour, Southampton Island, 1948. Appendix D in Part III. Botanical Associations of the Northern Biting Flies. Entomological Research in Northern Canada Progress Report. Defence Research Board, Canada. Report Number D.R. 20.

Cody, W. J. 1950. Plants collected by B. John Woodruff on the west coast of Melville Peninsula, Franklin District, N.W.T., Canada. Canadian Field-Naturalist 64: 90-92.

Cody, W. J. 1951a. Additions and annotations to the flora of Southampton Island, Northwest Territories, Canada. Canadian Field-Naturalist 65: 140-143.

Cody, W. J. 1951b. Plant collections at Ross Bay, Melville Peninsula, N.W.T. Canadian Field-Naturalist 65: 191-194.

Cody, W. J. 1952. *Chrysopsis falcata* adventive in Canada. Rhodora 54: 308.

Cody, W. J. 1953a. A plant collection from the west side of Boothia Isthmus, N.W.T., Canada. Canadian Field-Naturalist 67: 40-43.

Cody, W. J. 1953b. *Phyllodoce coerulea* in North America. Canadian Field-Naturalist 67: 131-134.

Cody, W. J. 1954a. New plant records from Bathurst Inlet, N.W.T. Canadian Field-Naturalist 68: 40.

Cody, W. J. 1954b. Plant records from Coppermine, Mackenzie District, N.W.T. Canadian Field-Naturalist 68: 110-117.

Cody, W. J. 1954c. *Salicornia europaea* in the James Bay region. Rhodora 56: 61-62.

Cody, W. J. 1954d. A history of *Tillaea aquatica* (Crassulaceae) in Canada and Alaska. Rhodora 56: 96-101.

Cody, W. J., and **B. Boivin.** 1954. The Canadian Field-Naturalist and its predecessors. Canadian Field-Naturalist 68: 127-132.

Boivin, B., and **W. J. Cody.** 1955. Bibliographic survey of James Fletcher's Flora Ottawaensis. Canadian Field-Naturalist 69: 79-82.

Cody, W. J. 1955. The glandular form of the Oak Fern. American Fern Journal 45: 126.

Cody, W. J., and **J. G. Chillcott.** 1955. Plant collections from Matthews and Muskox Lakes, Mackenzie District, N.W.T. Canadian Field-Naturalist 69: 153-162.

Schofield, W. B., and **W. J. Cody.** 1955. Botanical investigations on coastal southern Cornwallis Island, Franklin District, N.W.T. Canadian Field-Naturalist 69: 116-128.

Boivin, B., and **W. J. Cody.** 1956. The variations of *Lilium canadense* Linnaeus. Rhodora 58: 14-20.

Cody, W. J. 1956a. New plant records for northern Alberta and southern Mackenzie District. Canadian Field-Naturalist 70: 101-130.

Cody, W. J. 1956b. Ferns of the Ottawa District. Agriculture Canada Publication No. 974: 1-94.

Cody, W. J. 1957. *Draba lanceolata* in the Ottawa district. Rhodora 59: 237-239.

*Dore, W. G., F. H. Montgomery, S. C. Zoltai,** and **W. J. Cody.** 1959. Field trip 9, southern Ontario. IX International Botanical Congress. 40 pages.

Cody, W. J. 1960. Plants of the vicinity of Norman Wells, Mackenzie District, Northwest Territories. Canadian Field-Naturalist 74: 71-100.

Bowden, W. M., and **W. J. Cody.** 1961. Recognition of *Elymus sibiricus* L. from Alaska and the District of Mackenzie. Bulletin of the Torrey Botanical Club 88: 153-155.

Cody, W. J. 1961a. New plant records from the upper Mackenzie River valley, Mackenzie District, Northwest Territories. Canadian Field-Naturalist 75: 55-69.

Cody, W. J. 1961b. *Iris pseudacorus* L. escaped from cultivation in Canada. Canadian Field-Naturalist 75: 139-142.

Cody, W. J. 1961c. New forms in *Botrychium virginianum*. American Fern Journal 51: 36-37.

Cody, W. J. 1962a. *Sorbaria sorbifolia* (L.) A. Br. False Spiraea, persisting and spreading after cultivation in Canada. Canadian Field-Naturalist 76: 104-107.

Cody, W. J. 1962b. A new station for *Pinguicula vulgaris* in Ontario. Rhodora 64: 182-183.

Cody, W. J. 1963a. A contribution to the knowledge of the flora of southwestern Mackenzie District, N.W.T. Canadian Field-Naturalist 77: 108-123.

Cody, W. J. 1963b. Some rare plants from the Mackenzie Mountains, Mackenzie District, N.W.T. Canadian Field-Naturalist 77: 226-228.

Cody, W. J. 1963c. *Woodwardia* in Canada. American Fern Journal 53: 17-27.

*Cody, W. J.** 1963d. Reindeer Range Survey 1957 and 1963. Agriculture Canada, Plant Research Institute. 15 pages.

Cody, W. J. 1965a. New plant records from northwestern Mackenzie District, N.W.T. Canadian Field-Naturalist 79: 96-106.

*Cody, W. J.** 1965b. Plants of the Mackenzie River Delta and Reindeer Grazing Preserve. Canada Agriculture, Research Branch. 56 pages.

*[**Taylor, R. L.**, and **W. J. Cody**]. 1965. Canadian botanists. Agriculture Canada, Plant Research Institute. 55 pages.

*Cody, W. J.** 1966. New Herbarium Equipment. Agriculture Canada, Plant Research Institute. 7 pages.

Cody, W. J. 1967a. *Sedum* in the Ottawa District. Canadian Field-Naturalist 81: 273-274.

Cody, W. J. 1967b. *Elymus sibiricus* (Gramineae) new to British Columbia. Canadian Field-Naturalist 81: 275.

Cody, W. J. 1967c. The Plant Research Institute herbaria. Arboretum and Botanical Garden Bulletin 1: 17-20

Cody, W. J., and **A. E. Porsild.** 1967. *Potamogeton illinoensis*, new to Mackenzie District. Blue Jay 25: 28-29.

Hoffman, I., F. S. Nowosad, and **W. J. Cody**. 1967. Ascorbic acid and carotene values of native eastern Arctic plants. Canadian Journal of Botany 45: 1859-1862.

Cody, W. J. 1968. *Polystichum acrostichoides* × *lonchitis* versus *P.* × *marginale*. American Fern Journal 58: 30-31.

Cody, W. J., and **A. E. Porsild.** 1968. Additions to the flora of continental Northwest Territories, Canada. Canadian Field-Naturalist 82: 263-275.

Mulligan, G. A., and **W. J. Cody**. 1968a. *Draba norvegica*, disjunct to the Mackenzie District, Northwest Territories, Canada. Canadian Journal of Botany 46: 1334-1335.

Mulligan, G. A., and **W. J. Cody.** 1968b. Page 286 *in* IOPB chromosome number reports, XVII. *Edited by* Á. Löve. Taxon 17: 285-288.

Porsild, A. E., and **W. J. Cody.** 1968. Checklist of the Vascular Plants of Continental Northwest Territories. Agriculture Canada, Plant Research Institute. 102 pages.

Cody, W. J. 1969. *Asplenium trichomanes* new to Newfoundland. American Fern Journal 58: 179-180.

Hopkins, C. Y., M. J. Chisholm, and **W. J. Cody.** 1969. Fatty acid components of some Santalaceae seed oils. Phytochemistry 8: 161-165.

Mulligan, G. A., and **W. J. Cody.** 1969. The highest chromosome number known to occur in a North American plant. Canadian Field-Naturalist 83: 277-278.

Cody, W. J. 1970. *Paronychia fastigiata* (Caryophyllaceae), forked chickweed new to Ontario. Canadian Field-Naturalist 84: 58-59.

Cody, W. J. 1971a. A phytogeographic study of the floras of the continental Northwest Territories and Yukon. Le Naturaliste canadien 98: 145-158.

Cody, W. J. 1971b. Plant Research Institute botanical activities in northern Canada, 1948-1971. Greenhouse-Garden-Grass 10: 14-17.

Cody, W. J., and **C. Frankton.** 1971. Ragged Robin, *Lychnis flos-cuculi* L. (Caryophyllaceae), in Canada. Canadian Field-Naturalist 85: 256-257.

Mulligan, G. A., and **W. J. Cody.** 1971. Pages 613-614 *in* IOPB chromosome number reports XXXIII. *Edited by* Á. Löve. Taxon 20: 609-614.

Mason, W. R. M., G. E. Shewell, and **W. J. Cody.** 1972. A plant collection from the southern interior of Banks Island, N.W.T. Canadian Field-Naturalist 86: 363-367.

Mulligan, G. A., and **W. J. Cody.** 1972. Page 163 *in* IOPB chromosome number reports XXXV. *Edited by* Á. Löve. Taxon 21: 161-166.

Mulligan, G. A., L. Cinq-Mars, and **W. J. Cody.** 1972a. Natural interspecific hybridization between sexual and apogamous species of the beech fern genus *Phegopteris* Fée. Canadian Journal of Botany 50: 1295-1300.

Mulligan, G. A., W. J. Cody, and **N. Grainger.** 1972b. Pages 498-499 *in* IOPB chromosome number reports XXXVII. *Edited by* Á. Löve. Taxon 21: 495-500.

Cody, W. J. 1973. Ram's-head Lady's-slipper rediscovered in Saskatchewan. Blue Jay 31: 180-181.

Cody, W. J., and **B. Boivin.** 1973. Purple Coneflower, *Echinacea purpurea*, in Ontario. Canadian Field-Naturalist 87: 70.

Cody, W. J., and **K. Shaw.** 1973. Canada plum in southwestern Alberta. Blue Jay 31: 217-218.

Cody, W. J., and **K. W. Spicer.** 1973. Report on the vascular plant herbarium – 1972. Greenhouse-Garden-Grass 12: 27-32.

Cody, W. J., and **S. S. Talbot.** 1973. The pitcher plant, *Sarracenia purpurea* L. in the northwestern part of its range. Canadian Field-Naturalist 87: 318-320.

Mulligan, G. A., and **W. J. Cody.** 1973a. Pages 290-291 *in* IOPB chromosome number reports XL. *Edited by* Á. Löve. Taxon 22: 285-291.

Mulligan, G. A., and **W. J. Cody.** 1973b. A clarification of the chromosome number situation in *Sanguisorba canadensis*. Canadian Journal of Botany 51: 2075-2077.

Cody, W. J., and **W. Krivda.** 1974. *Carex maritima* Gunn., an adventive sedge at The Pas, Manitoba. Blue Jay 32: 25-26.

Cody, W. J., B. Boivin, and **G. W. Scotter.** 1974. *Loiseleuria procumbens* (L.) Desv., Alpine Azalea, in Alberta. Canadian Field-Naturalist 88: 229-230.

Mulligan, G. A., and **W. J. Cody.** 1974. Page 194 *in* IOPB chromosome number reports XLIII. *Edited by* Á. Löve. Taxon 23: 193-196.

Scotter, G. W., and **W. J. Cody.** 1974. Vascular plants of Nahanni National Park and vicinity, Northwest Territories. Le Naturaliste canadien 101: 861-891.

*__Simmons, N.M.__ and **W. J. Cody.** 1974. A proposal for Ecological Reserves in the Northwest Territories: Plains of Abraham, Glacier Lake, Brackett Lake, Pilot Lake. Canadian Committee for the International Biological Program, Conservation of Terrestrial Ecosystems, Panel 10. 174 pages.

Wein, R. W., L. R. Hettinger, A. J. Janz, and **W. J. Cody.** 1974. Vascular plant range extensions in the northern Yukon Territory and northwestern Mackenzie District, Canada. Canadian Field-Naturalist 88: 57-66.

Cody, W. J. 1975a. *Scheuchzeria palustris* L. (Scheuchzeriaceae) in northwestern North America. Canadian Field-Naturalist 89: 69-71.

*__Cody, W. J.__ 1975b. A phytogeographical study of the flora of St. Lawrence Islands National Park region. St. Lawrence Islands National Park Interpretation Contract. 65 pages + Appendix 1. The vascular plants of the Thousand Islands National Park region. 68 pages.

Cody, W. J., and **C. W. Crompton.** 1975. The biology of Canadian weeds. 15. *Pteridium aquilinum* (L.) Kuhn. Canadian Journal of Plant Science 55: 1059-1072.

Cody, W. J., and **J. D. Lafontaine.** 1975. The fern genus *Woodsia* in Manitoba. Canadian Field-Naturalist 89: 66-69.

Cody, W. J., and **R. B. MacLaren.** 1976. Additions and rediscoveries of five plant species in Prince Edward Island. Canadian Field-Naturalist 90: 53-54.

Cody, W. J., G. R. Parker, and **D. B. M. Lamperd.** 1976. Additions to the vascular flora of Melville Island, Franklin District, Northwest Territories. Canadian Field-Naturalist 90: 70-72.

*__Cody, W. J.__ 1977. Ralph Anthony Ludwig. Bulletin of the Canadian Botanical Association 10(2): 14-15.

Cody, W. J., I. V. Hall, and **C. W. Crompton.** 1977. The biology of Canadian weeds. 26. *Dennstaedtia punctilobula* (Michx.) Moore. Canadian Journal of Plant Science 57: 1159-1168.

Cody, W. J. 1978a. Ferns of the Ottawa District. (Revised). Agriculture Canada, Research Branch Publication 974. 112 pages. [made available in French in 1980. Fougères du district d'Ottawa. Agriculture Canada, Direction de la recherche, Publication 974. 112 pages.]

*__Cody, W. J.__ 1978b. Plants of the Thousand Islands. Island Insights No. 1. Parks Canada, Cornwall, Ontario. 63 pages.

Cody, W. J. 1978c. The status of *Lythrum alatum* (Lythraceae) in Canada. Canadian Field-Naturalist 92: 74-75.

Cody, W. J. 1978d. Range extensions and comments on the vascular flora of the continental Northwest Territories. Canadian Field-Naturalist 92: 144-150.

Cody, W. J., and **S. S. Talbot.** 1978. Vascular plant range extensions to the Heart Lake area, District of Mackenzie, Northwest Territories. Canadian Field-Naturalist 92: 137-143.

McNeill, J., and **W. J. Cody.** 1978. Species-area relationships for vascular plants of some St. Lawrence River islands. Canadian Field-Naturalist 92: 10-18.

Soper, J. H., and **W. J. Cody.** 1978a. Alf Erling Porsild, M.B.E., F.R.S.C. (1901-1977). Canadian Field-Naturalist 92: 299-304.

*Soper, J. H., and W. J. Cody. 1978b. The publications of Dr. A. E. Porsild. Bulletin of the Canadian Botanical Association 11(2): 28-32.

Cody, W. J. 1979. Vascular plants of restricted range in the continental Northwest Territories, Canada. Syllogeus (National Museum of Natural Sciences) 23. 57 pages.

Cody, W. J., G. W. Scotter, and **S. S. Talbot.** 1979. Additions to the vascular plant flora of Nahanni National Park, Northwest Territories. Le Naturaliste canadien 106: 439-450.

Mulligan, G. A., and **W. J. Cody.** 1979. Chromosome numbers in Canadian *Phegopteris*. Canadian Journal of Botany 57: 1815-1819.

Nagy, J. A., A. M. Pearson, B. C. Goski, and **W. J. Cody.** 1979. Range extensions of vascular plants in northern Yukon Territory and northwestern District of Mackenzie. Canadian Field-Naturalist 93: 259-265.

Scotter, G. W., and **W. J. Cody.** 1979. Interesting vascular plants from southeastern Yukon Territory. Canadian Field-Naturalist 93: 163-170.

Cody, W. J. 1980. *Wolffia columbiana* (Lemnaceae), water-meal, new to Manitoba. Canadian Field-Naturalist 94: 193-194.

Cody, W. J., and **D. Munro.** 1980. The genus *Listera* (Twayblades) in New Brunswick. Canadian Field-Naturalist 94: 443-446.

Gillett, J. M. 1980. Edited by **W. J. Cody**. Transactions of the Ottawa Field-Naturalists' Club and the Ottawa Naturalist Index. Ottawa Field-Naturalists' Club Special Publication No. 2. 195 pages.

Porsild, A. E., and **W. J. Cody.** 1980. Vascular plants of continental Northwest Territories. National Museum of Natural Sciences, Ottawa. 667 pages.

Cody, W. J., and **V. Wagner.** 1981. The biology of Canadian weeds. 49. *Equisetum arvense* L. Canadian Journal of Plant Science 61: 123-133.

Cody, W. J. 1982. A comparison of the northern limits of distribution of some vascular plant species found in southern Ontario. Le Naturaliste canadien 109: 63-90.

Cody, W. J., and **G. A. Mulligan.** 1982. Chromosome numbers of some Canadian ferns and fern allies. Le Naturaliste canadien 109: 273-275.

Cody, W. J. 1983a. *Adiantum pedatum* ssp. *calderi*, a new subspecies in northeastern North America. Rhodora 85: 93-96.

Cody, W. J. 1983b. Plant collecting in Ontario: the view from DAO. The Plant Press 1(2): 27-28.

Cody, W. J., and **D. M. Britton.** 1984. *Polystichum lemmonii*, a rock shield-fern new to British Columbia and Canada. Canadian Field-Naturalist 98: 375.

Cody, W. J., and **J. Saquet.** 1984. Pinesap, *Monotropa hypopithys*, new to the flora of Manitoba. Canadian Field-Naturalist 98: 256-257.

Cody, W. J., G. W. Scotter, and **S. C. Zoltai.** 1984a. Additions to the vascular plant flora of the Bathurst Inlet region, Northwest Territories, Canada. Canadian Field-Naturalist 98: 171-177.

Cody, W. J., G. W. Scotter, and **S. C. Zoltai.** 1984b. Additions to the vascular plant flora of Bylot Island, Northwest Territories. Canadian Field-Naturalist 98: 485-488.

Britton, D. M., W. G. Stewart, and **W. J. Cody.** 1985. *Cystopteris protrusa*, Creeping Fragile Fern, an addition to the flora of Canada. Canadian Field-Naturalist 99: 380-382.

*Cody, W. J. 1985. In Memoriam, Bernard Boivin, F.R.S.C. Canadian Botanical Association Bulletin 18(3): 21.

Cody, W. J., and **D. M. Britton.** 1985. Male Fern, *Dryopteris filix-mas*, a phytogeographically important discovery in northern Saskatchewan. Canadian Field-Naturalist 99: 101-102.

Cody, W. J. 1986a. Agriculture Canada Research Branch Centennial 1886-1986. Canadian Field-Naturalist 100: 418-422.

Cody, W. J. 1986b. Compactor systems installed for DAO and DAOM herbaria. The Plant Press 4: 100-101.

Cody, W. J., and **J. Cayouette.** 1986. A tribute to Bernard Boivin, 1916-1985. Canadian Field-Naturalist 100: 280-288.

Cody, W. J., and **W. L. Putman.** 1986. A hawk's-beard, *Crepis pulchra*, adventive in Ontario. Canadian Field-Naturalist 100: 376-377.

Cody, W. J., D. B. O. Savile, and **M. J. Sarazin.** 1986. Systematics in Agriculture Canada at Ottawa 1886-1986. Agriculture Canada Historical Series No. 28. 81 pages. / La Recherche en systématique à Agriculture Canada 1886-1986. 83 pages.

Parmelee, J. A., and **W. J. Cody.** 1986. Compactor installations for collections of fungi and plants in the Biosystematics Research Centre. Agriculture Canada Publication. 8 pages.

Barr, D. J. S., W. J. Cody, and **J. A. Parmelee.** 1987. State-of-the-art herbarium compactor systems for DAO and DAOM. Taxon 36: 413-421.

Catling, P. M., and **W. J. Cody.** 1987. Botanical research in Canadian parks. Park News Magazine (Summer): 13-15.

Cody, W. J. 1988a. Hornseed Buttercup, *Ceratocephalus testiculatus*: a new record for the adventive flora of Saskatchewan. Canadian Field-Naturalist 102: 71-73.

Cody, W. J. 1988b. Plants of Riding Mountain National Park, Manitoba. Agriculture Canada, Research Branch Publication 1818/E. 320 pages. [Also made available in French, 1988. Flore du Parc national du mont Riding, Manitoba. Agriculture Canada, Direction générale de la recherche, Publication 1818/F. 340 pages.]

Cody, W. J., and **F. W. Schueler.** 1988. A second record of the Mosquito Fern, *Azolla caroliniana*, in Ontario. Canadian Field-Naturalist 102: 545-546.

Cody, W. J., M. Blondeau, and **J. Cayouette.** 1988. *Ranunculus × spitzbergensis* (Nath.) Hadač, an addition to the flora of North America. Rhodora 90: 27-36.

Cayouette, J., and **W. J. Cody.** 1989. Bernard Boivin (1916 Quatre-Temps (SAJIB [Société d'animation du Jardin et de l'Institut botaniques]) 13(3): 2-11.

Cody, W. J., and **D. M. Britton**. 1989. Ferns and fern allies of Canada. Agriculture Canada, Research Branch Publication 1829/E. 430 pages. [Also made available in French, 1989. Les fougères et les plantes alliées du Canada. Agriculture Canada, Direction générale de la recherche, Publication 1829/F. 452 pages.]

Cody, W. J., G. W. Scotter, and **S. C. Zoltai.** 1989. Vascular plant flora of the Wager Bay region, District of Keewatin, Northwest Territories. Canadian Field-Naturalist 103: 551-559.

*Cody, W. J. 1990. Recent death. James (Jim) A. Calder. Herbarium News 10(3): 19. Also reproduced in Canadian Botanical Association Bulletin 23(2): 21, 1990.

Cody, W. J., and **G. W. Scotter.** 1990. New records for the Alberta flora: *Geranium pratense*, Meadow Crane's-bill,

and *Anemone canadensis* f. *dicksonii*, a Canada Anemone form. Canadian Field-Naturalist 104: 600-602.

Cody, W. J., S. J. Darbyshire, and **C. E. Kennedy**. 1990. A Bluegrass, *Poa pseudoabbreviata* Roshev., new to the flora of Canada, and some additional records from Alaska. Canadian Field-Naturalist 104: 589-591.

Cody, W. J., and **J. Cayouette.** 1991. A tribute to James Alexander Calder, 1915-1990. Canadian Field-Naturalist 105: 584-591.

***Cody, W. J.** 1992. Type specimens in DAO. Herbarium News 12(5/6): 20.

Cody, W. J., G. W. Scotter, and **S. C. Zoltai.** 1992. Vascular plant flora of the Melville Hills region, Northwest Territories. Canadian Field-Naturalist 106: 87-99.

Wein, R. W., G. Wein, S. Bahret, and **W. J. Cody.** 1992. Northward invading non-native vascular plant species in and adjacent to Wood Buffalo National Park, Canada. Canadian Field-Naturalist 106: 216-224.

Cody, W. J. 1994a. Nomenclatural changes and new taxa for the Yukon flora. Canadian Field-Naturalist 108: 93-95.

Cody, W. J. 1994b. The flora of the Yukon Territory: additions, range extensions and comments. Canadian Field-Naturalist 108: 428-476. [See also addendum 109: 266. 1995.]

Lichvar, R. W., and **W. J. Cody.** 1994. Yukon, *Botrychium multifidum* (Gmel.) Rupr. var. *multifidum* (Ophioglossaceae). Madroño 41: 232-233.

McJannet, C. L., G. W. Argus, and **W. J. Cody.** 1995. Rare vascular plants in the Northwest Territories. Syllogeus No. 73. 104 pages.

Mulligan, G. A., and **W. J. Cody.** 1995. New information on the problem of Asiatic Cress, *Rorippa crystallina* Rollins (Brassicaceae). Canadian Field-Naturalist 109: 111-112.

Cody, W. J. 1996a. Additions and range extensions to the vascular plant flora of the Northwest Territories, Canada. Canadian Field-Naturalist 110: 260-270.

Cody, W. J. 1996b. Flora of the Yukon Territory. NRC Research Press, Ottawa, Ontario, Canada. 643 pages.

***Cody, W. J.** 1996c. Catalogue of Type Specimens in the Vascular Plant Herbarium (DAO). Internet http://res.agr.ca/brd/dao. [Updated in 2000, 2002 and 2003]

Cody, W. J. 1997. A tribute to Harold Archie Senn, 1912-1997. Canadian Field-Naturalist 111: 671-675.

Cody, W. J. 1998a. A tribute to Hugh Miller Raup, 1901-1995. Canadian Field-Naturalist 112: 557-564.

Cody, W. J. 1998b. Horned Pondweed, *Zannichellia palustris* (Zannichelliaceae), new to the vascular plant flora of the continental Northwest Territories, Canada, and deleted from the flora of the Yukon Territory. Canadian Field-Naturalist 112: 711-712.

Cody, W. J., C. E. Kennedy, and **B. Bennett.** 1998. New records of vascular plants in the Yukon Territory. Canadian Field-Naturalist 112: 289-328.

Cody, W. J. 2000a. Flora of the Yukon Territory. Second edition. NRC Research Press, Ottawa. 669 pages.

Cody, W. J. 2000b. Addendum, Flora of the Yukon Territory. NRC Research Press, Ottawa, Ontario, Canada. 24 pages.

Cody, W. J. and **K. L. MacInnes.** 2000. Head Smut, *Ustilago bullata* on Slender Wheat Grass, *Elymus trachycaulus*, introduced along the Norman Wells pipeline, District of Mackenzie, Northwest Territories. Canadian Field-Naturalist 114: 138-141.

Cody, W. J., C. E. Kennedy, and **B. Bennett**. 2000a. New records of vascular plants in the Yukon Territory II. Canadian Field-Naturalist 114: 417-443.

Cody, W. J., K. L. MacInnes, J. Cayouette, and **S. Darbyshire**. 2000b. Alien and invasive native vascular plants along the Norman Wells pipeline, District of Mackenzie, Northwest Territories. Canadian Field-Naturalist 114: 126-137.

Cody, W. J., C. E. Kennedy, and **B. Bennett.** 2001. New records of vascular plants in the Yukon Territory III. Canadian Field-Naturalist 115: 301-322.

Cody, W. J. 2002. *Dryopteris ×mickelii* Peck, Simulated Log Fern, a newly named hybrid fern found in the Ottawa District. Trail & Landscape 36(2): 43-45.

Cody, W. J., C. E. Kennedy, B. Bennett, and **V. Loewen.** 2002. New records of vascular plants in the Yukon Territory IV. Canadian Field-Naturalist 116: 446-474.

Staniforth, R. J., W. J. Cody, and **K. A. Frego.** 2002. Bill Dore's notes on the Kaladar Cactus (*Opuntia fragilis*). Canadian Field-Naturalist 116: 547-550.

Cody, W. J., and **V. Johnston**. 2003. *Malaxis monophyllos* var. *brachypoda*, One-leaved Malaxis, new to the Northwest Territories, Canada. Canadian Field-Naturalist 117: 302-303.

Cody, W. J., C. E. Kennedy, B. Bennett, and **J. Staniforth**. 2003a. New records of vascular plants in the Yukon Territory V. Canadian Field-Naturalist 117: 278-301.

Cody, W. J., K. L. Reading, and **J. M. Line.** 2003b. Additions and range extensions to the vascular plant flora of the continental Northwest Territories and Nunavut, Canada, II. Canadian Field-Naturalist 117: 448-465.

***Cody, W. J.** and **C. E. Kennedy.** 2004. Flora of Herschel Island Territorial Park (checklist). Yukon Environment. 2 pages.

Cody, W. J., C. E. Kennedy, B. Bennett, and **P. Caswell.** 2004. New records of vascular plants in the Yukon Territory VI. Canadian Field-Naturalist 118: 558-578.

Catling, P. M., W. J. Cody, and **G. Mitrow.** 2005. A compilation of additions to the flora of the continental portions of Northwest Territories and Nunavut. Botanical Electronic News 352: 3-12. http://www.ou.edu/cas/botany-micro/ben/ben353.html.

Cody, W. J., and **K. L. Reading.** 2005. Additions and range extensions to the vascular plant flora of the continental Northwest Territories and Nunavut, Canada III. Canadian Field-Naturalist 119: 276-290.

Cody, W. J., B. A. Bennett, and **P. Caswell.** 2005. New records of vascular plants in the Yukon territory VII. Canadian Field-Naturalist 119: 417-436.

Bennett, B. A., P. M. Catling, W. J. Cody, and **G. W. Argus**. 2010. New records of vascular plants in the Yukon Territory VIII. Canadian Field-Naturalist 124(1): 1-27.

Appendix 2. W. J. Cody – Miscellaneous publications

Cody, W. J. 1960. Review of T. S. Cooperrider, *The ferns and other pteridophytes of Iowa*. Canadian Field-Naturalist 74: 58.

Cody, W. J. 1963. Index Seminum. Agriculture Canada, Plant Research Institute. 40 pages.

Cody, W. J. 1964. Index Seminum. Agriculture Canada, Plant Research Institute. 38 pages.

Cody, W. J. 1965. Index Seminum. Agriculture Canada, Plant Research Institute. 33 pages.

Cody, W. J. 1966a. Review of T. M. C. Taylor, *The lily family (Liliaceae) of British Columbia*. Canadian Field-Naturalist 80: 246.

Cody, W. J. 1966b. Review of T. M. C. Taylor, *Vascular flora of British Columbia – preliminary check list*. Canadian Field-Naturalist 80: 247.

Cody, W. J. 1966c. Index Seminum. Agriculture Canada, Plant Research Institute. 21 pages.

Cody, W. J. 1967a. Review of R. H. Mohlenbrock, *The illustrated flora of Illinois: ferns*. Canadian Field-Naturalist 81: 296-297.

Cody, W. J. 1967b. Index Seminum. Agriculture Canada, Plant Research Institute. 21 pages.

Cody, W. J. 1967c. Review of F. H. Montgomery, *Plants from sea to sea*. Economic Botany 21: 196.

Cody, W. J. 1968a. Review of R. G. H. Cormack, *Wild flowers of Alberta*. Canadian Field-Naturalist 82: 300.

Cody, W. J. 1968b. Review of W. G. Hardy, *Alberta – A natural history*. Greenhouse-Garden-Grass 7: 22.

Cody, W. J. 1968c. Index Seminum. Agriculture Canada, Plant Research Institute. 22 pages.

Cody, W. J. 1969a. Review of A. Feininger, *Trees*. Canadian Field-Naturalist 83: 71.

Cody, W. J. 1969b. Review of D. Archibald et al., *Quick-key guide to wildflowers of northeastern and central United States and adjacent Canada*. Canadian Field-Naturalist 83: 179.

Cody, W. J. 1969c. Review of J. S. Maini and J. B. Cayford (editors), *Growth and utilization of poplars in Canada*. Canadian Field-Naturalist 83: 288-289.

Cody, W. J. 1969d. Review of E. Hultén, *Flora of Alaska and neighboring territories: a manual of the vascular plants*. Canadian Field-Naturalist 83: 412-413.

Cody, W. J. 1969e. Review of A. E. Radford et al., *Manual of the vascular flora of the Carolinas*. Canadian Field-Naturalist 83: 417.

Cody, W. J. 1969f. Review of C. F. Brockman, *Trees of North America: a field guide to the major native and introduced species north of Mexico*. Canadian Field-Naturalist 83: 419.

Cody, W. J. 1969g. Index Seminum. Agriculture Canada, Plant Research Institute. 28 pages.

Cody, W. J. 1970a. Review of F. Marie-Victorin and F. Rolland-Germain, *Flore de l'Anticosti-Minganie*. Canadian Field-Naturalist 84: 72.

Cody, W. J. 1970b. Review of C. L. Hitchcock et al., *Vascular plants of the Pacific Northwest, Part I: vascular cryptograms, gymnosperms and monocotyledons*. Canadian Field-Naturalist 84: 200.

Cody, W. J. 1970c. Review of W. G. Stewart and L. E. James, *A guide to the flora of Elgin County, Ontario*. Canadian Field-Naturalist 84: 327.

Cody, W. J. 1970d. Index Seminum. Agriculture Canada, Plant Research Institute. 24 pages.

Cody, W. J. 1971a. Review of T. M. C. Taylor, *Pacific Northwest ferns and their allies*. Canadian Field-Naturalist 85: 83.

Cody, W. J. 1971b. Review of R. A. Nelson, *Handbook of Rocky Mountain plants*. Canadian Field-Naturalist 85: 196.

Cody, W. J. 1971c. Review of R. J. Preston Jr., *Rocky Mountain trees*. Canadian Field-Naturalist 85: 346.

Cody, W. J. 1971d. Review of H. L. Keeler, *Our northern shrubs and how to identify them*. Canadian Field-Naturalist 85: 346-347.

Cody, W. J. 1971e. Index Seminum. Agriculture Canada, Plant Research Institute. 24 pages.

Cody, W. J. 1972a. Review of J. Mirsky, *To the Arctic! The story of northern explorers from earliest times to the present*. Canadian Field-Naturalist 86: 108.

Cody, W. J. 1972b. Review of A. W. Taylor, *Wild flowers of the Pyrenees*. Canadian Field-Naturalist 86: 411-412.

Cody, W. J. 1972c. Index Seminum. Agriculture Canada, Plant Research Institute. 36 pages.

Cody, W. J. 1973a. Review of W. A. Weber, *Rocky Mountain flora*, fourth edition. Canadian Field-Naturalist 87: 194.

Cody, W. J. 1973b. Review of A. Cronquist et al., *Intermountain flora: vascular plants of the Intermountain West, U.S.A. Volume 1. Geological and botanical history of the region, its plant geography and a glossary, the vascular cryptograms and the gymnosperms*. Canadian Field-Naturalist 87: 329-330.

Cody, W. J. 1973c. Review of E. G. Voss, *Michigan flora: a guide to the identification and occurrence of the native and naturalized seed-plants of the state. Part I. Gymnosperms and monocots*. Canadian Field-Naturalist 87: 330.

Cody, W. J. 1973d. Review of C. L. Hitchcock and A. Cronquist, *Flora of the Pacific Northwest – an illustrated manual*. Canadian Field-Naturalist 87: 475.

Cody, W. J. 1973e. Index Seminum. Agriculture Canada, Plant Research Institute. 37 pages.

Cody, W. J. 1974a. Review of R. H. Mohlenbrock and J. Voigt, *A flora of southern Illinois*. Canadian Field-Naturalist 88: 531.

Cody, W. J. 1974b. Review of J. Jalas and J. Suominen, *Atlas Florae Europaeae: distribution of vascular plants in Europe*. Canadian Field-Naturalist 88: 533-534.

Cody, W. J. 1974c. Review of *The milepost – All-the-North travel guide (Alaska-The Yukon-Northern British Columbia-Northwest Territories)*. Canadian Field-Naturalist 88: 546.

Cody, W. J. 1974d. Review of Z. Zuccoli, *Flora arctica*. Economic Botany 28: 413, 448.

Cody, W. J. 1975a. Review of C. Rousseau, *Géographie floristique du Québec/Labrador. Distribution des principales espèces vasculaires*. Canadian Field-Naturalist 89: 198.

Cody, W. J. 1975b. Review of S. Osborn (editor), *The discovery of the Northwest Passage by H.M.S. "Investigator", Captain R. M'Clure 1850, 1851, 1852, 1853, 1854,* and C. F. Hall, *Life with the Esquimaux, a narrative of arctic experience in search of survivors of Sir John Franklin's expedition*. Canadian Field-Naturalist 89: 203-204.

Cody, W. J. 1975c. Review of H. A. Stephens, *Woody plants of the north central plains*. Canadian Field-Naturalist 89: 95.

Cody, W. J. 1975d. Review of H. A. White and M. Williams, *The Alaska-Yukon wild flowers guide*. Canadian Field-Naturalist 89: 339.

Cody, W. J. 1976a. Review of R. T. Clausen, *Sedum of North America north of the Mexican Plateau*. Canadian Field-Naturalist 90: 210-211.

Cody, W. J. 1976b. Review of *Flore du Canada*. Canadian Field-Naturalist 90: 211.

Cody, W. J. 1977a. Review of A. Potvin, *A panorama of Canadian forests*. Canadian Field-Naturalist 91: 206.

Cody, W. J. 1977b. Review of M. Ferguson and R. M. Saunders, *Canadian wildflowers*. Canadian Field-Naturalist 91: 206.

Cody, W. J. 1977c. Review of W. A. Weber, *Rocky Mountain flora*, fifth edition. Canadian Field-Naturalist 91: 207.

Cody, W. J. 1977d. Review of R. H. Mohlenbrock, *Guide to the vascular flora of Illinois*. Canadian Field-Naturalist 91: 207.

Cody, W. J. 1977e. Review of F. R. Vance et al., *Wildflowers across the Prairies*. Canadian Field-Naturalist 91: 334.

Cody, W. J. 1977f. Review of N. C. Fassett, *Spring flora of Wisconsin*. Canadian Field-Naturalist 91: 334.

Cody, W. J. 1978a. Review of T. Van Bruggen, *The vascular plants of South Dakota*. Canadian Field-Naturalist 92: 102.

Cody, W. J. 1978b. Review of R. L. Taylor and B. MacBryde, *Vascular plants of British Columbia – A descriptive resource inventory*. Canadian Field-Naturalist 92: 103-104.

Cody, W. J. 1978c. Review of A. Cronquist et al., *Intermountain flora: vascular plants of the Intermountain West, U.S.A. Volume 6. The monocotyledons*. Canadian Field-Naturalist 92: 312-313.

Cody, W. J. 1978d. Review of R. L. McGregor and T. M. Barkley, *Atlas of the flora of the Great Plains*. Canadian Field-Naturalist 92: 313.

Cody, W. J. 1978e. Review of J. H. Hudson, Carex *in Saskatchewan*. Canadian Field-Naturalist 92: 414.

Cody, W. J. 1979a. Review of R. D. Dorn, *Manual of the vascular plants of Wyoming*. Canadian Field-Naturalist 93: 211.

Cody, W. J. 1979b. Review of S. G. Shetler and L. E. Skog, *A provisional checklist of species for Flora North America (Revised)*. Canadian Field-Naturalist 93: 212.

Cody, W. J. 1979c. Review of J. P. Smith Jr., *Vascular plant families*. Canadian Field-Naturalist 93: 457.

Cody, W. J. 1980a. Review of L. C. Linn, *Eastern North America's wildflowers*. Canadian Field-Naturalist 94: 102.

Cody, W. J. 1980b. Review of V. Ahmadjian, *Flowering plants of Massachusetts*. Canadian Field-Naturalist 94: 210.

Cody, W. J. 1980c. Review of A. J. Petrik-Ott, *The pteridophytes of Kansas, Nebraska, South Dakota and North Dakota*. Canadian Field-Naturalist 94: 211.

Cody, W. J. 1980d. Review of R. G. Bryan and N. E. Newton-White, *Wildflowers of the North*. Canadian Field-Naturalist 94: 484.

Cody, W. J. 1980e. Review of J. L. Riley and S. M. McKay, *The vegetation and phytogeography of coastal southwestern James Bay*. Ontario Field Biologist 34(2): 108.

Cody, W. J. 1981a. Review of A. Cronquist, *Vascular flora of the southeastern United States. Volume 1. Asteraceae*. Canadian Field-Naturalist 95: 119.

Cody, W. J. 1981b. Review of M. Laird, *Bibliography of the natural history of Newfoundland and Labrador*. Canadian Field-Naturalist 95: 382.

Cody, W. J. 1981c. Review of R. B. Freeman, *British natural history books, 1495-1900: a handlist*. Canadian Field-Naturalist 95: 497.

Cody, W. J. 1982. Review of R. W. Becking, *Pocket flora of the redwood forest*. Canadian Field-Naturalist 96: 501.

Cody, W. J. 1983a. Review of L. Benson, *The cacti of the United States and Canada*. Canadian Field-Naturalist 97: 137.

Cody, W. J. 1983b. Review of G. W. Douglas et al., *The rare vascular plants of the Yukon*. Canadian Field-Naturalist 97: 241-242.

Cody, W. J. 1984a. Review of F. C. Seymour, *The flora of New England: a manual for the identification of all vascular plants including ferns and fern allies growing without cultivation in New England*, second edition. Canadian Field-Naturalist 98: 142.

Cody, W. J. 1984b. Review of J. G. Trelawny, *Wildflowers of the Yukon and northwestern Canada including adjacent Alaska*. Canadian Field-Naturalist 98: 269.

Cody, W. J. 1984c. Review of Á. Löve, *Flora of Iceland*. Canadian Field-Naturalist 98: 270.

Cody, W. J. 1984d. Review of M. Ferguson and R. M. Saunders, *Canadian wildflowers through the seasons*, and M. Ferguson, *Canadian wildflowers 1985*. Canadian Field-Naturalist 98: 271.

Cody, W. J. 1984e. Review of E. H. Moss, *Flora of Alberta*, second edition, revised by J. G. Packer. Canadian Field-Naturalist 98: 408-409.

Cody, W. J. 1984f. Review of J. M. Webber, *The vascular plant flora of Peel County, Ontario*. The Plant Press 2(4): 112-113.

Cody, W. J. 1985a. Review of A. Cronquist et al., *Intermountain flora: vascular plants of the Intermountain West, U.S.A. Volume 4. Subclass Asteridae (except Asteraceae)*. Canadian Field-Naturalist 99: 126-127. 191.

Cody, W. J. 1985b. Review of D. Griffin, *Atlantic wildflowers*. Canadian Field-Naturalist 99: 556.

Cody, W. J. 1985c. Review of F. R. Vance, J. R. Jowsey, and J. S. McLean, *Wildflowers across the prairies*, revised and expanded. Canadian Field-Naturalist 99: 557.

Cody, W. J. 1985d. Club Moss. Page 361 *in* The Canadian Encyclopedia 1. Hurtig, Edmonton.

Cody, W. J. 1985e. Fern. Pages 623-624 *in* The Canadian Encyclopedia 1. Hurtig, Edmonton.

Cody, W. J. 1985f. Horsetail. Pages 832-833 *in* The Canadian Encyclopedia 2. Hurtig, Edmonton.

Cody, W. J. 1985g. Porsild, Alf Erling. Page 1456 *in* The Canadian Encyclopedia 3. Hurtig, Edmonton.

Cody, W. J. 1986a. Review of J. C. Ritchie, *Past and present vegetation of the Far Northwest of Canada*. Canadian Field-Naturalist 100: 153.

Cody, W. J. 1986b. Review of D. T. MacRoberts, *The vascular plants of Louisiana: an annotated checklist and bibliography of the vascular plants reported to grow without cultivation in Louisiana*. Canadian Field-Naturalist 100: 304.

Cody, W. J. 1986c. Review of A. Farjon, *Pines, drawings and descriptions of the genus* Pinus. Canadian Field-Naturalist 100: 305-306.

Cody, W. J. 1986d. Review of I.-C. Chung, *The Arctic and the Rockies as seen by a botanist Pictorial*. Canadian Field-Naturalist 100: 588.

Cody, W. J. 1987a. Fougère. Page 780 *in* L'Encyclopédie du Canada 2. Stanké, Montréal.

Cody, W. J. 1987b. Lycopode. Page 1140 *in* L'Encyclopédie du Canada 2. Stanké, Montréal.

Cody, W. J. 1987c. Porsild, Alf Erling. Page 1557 *in* L'Encyclopédie du Canada 3. Stanké, Montréal.

Cody, W. J. 1987d. Prêle. Page 1573 *in* L'Encyclopédie du Canada 3. Stanké, Montréal.

Cody, W. J. 1987e. Review of T. Van Bruggen, *The vascular plants of South Dakota,* second edition. Canadian Field-Naturalist 101: 317.

Cody, W. J. 1987f. Review of G. W. Scotter and H. Flygare, *Wildflowers of the Canadian Rockies*. Canadian Field-Naturalist 101: 318-319.

Cody, W. J. 1987g. Review of A. F. Clewell, *Guide to the vascular plants of the Florida Panhandle*. Canadian Field-Naturalist 101: 319.

Cody, W. J. 1987h. Review of A. Strid, *Mountain flora of Greece, Volume 1*. Canadian Field-Naturalist 101: 506.

Cody, W. J. 1987i. Review of Great Plains Flora Association, *Flora of the Great Plains*. Canadian Field-Naturalist 101: 507-508.

Cody, W. J. 1987j. Review of E. G. Voss, *Michigan flora: a guide to the identification and occurrence of the native and naturalized seed plants of the state, Part II: Dicots (Saururaceae – Cornaceae)*. Canadian Field-Naturalist 101: 650-651.

Cody, W. J. 1988a. Review of E. A. Cope, *Native and cultivated conifers of northeastern North America: a guide*. Canadian Field-Naturalist 102: 187.

Cody, W. J. 1988b. Review of S. L. Welsh, *A Utah flora*. Canadian Field-Naturalist 102: 406-407.

Cody, W. J. 1988c. Review of A. R. Clapham, T. G. Tutin, and D. M. Moore, *Flora of the British Isles*, third edition. Canadian Field-Naturalist 102: 407-408.

Cody, W. J. 1988d. Review of J. Hayward, *A new key to wild flowers*. Canadian Field-Naturalist 102: 602-603.

Cody, W. J. 1988e. Club Moss. Page 445 *in* The Canadian Encyclopedia (2nd edition) 1.

Cody, W. J. 1988f. Fern. Pages 758-759 *in* The Canadian Encyclopedia (2nd edition) 2.

Cody, W. J. 1988g. Horsetail. Pages 1008-1009 *in* The Canadian Encyclopedia (2nd edition) 2.

Cody, W. J. 1988h. Porsild, Alf Erling. Page 1724 *in* The Canadian Encyclopedia (2nd edition) 3.

Cody. W. J. 1989a. Review of L. Couillard et al., *The rare plants of the Mingan Archipelago*. Canadian Field-Naturalist 103: 126.

Cody, W. J. 1989b. Review of W. A. Weber, *Colorado flora: Western Slope*. Canadian Field-Naturalist 103: 126-127.

Cody, W. J. 1989c. Review of J. C. Ritchie, *Postglacial vegetation of Canada*. Canadian Field-Naturalist 103: 463.

Cody, W. J. 1989d. Review of B. J. Albee et al., *Atlas of the vascular plants of Utah*. Canadian Field-Naturalist 103: 463-464.

Cody, W. J. 1989e. Review of A. Johnson, *Plants and the Blackfoot*. Canadian Field-Naturalist 103: 626.

Cody, W. J. 1990a. Review of R. J. Shaw, *Vascular plants of northern Utah – an identification manual*. Canadian Field-Naturalist 104: 619-620.

Cody, W. J. 1990b. Review of G. W. Douglas et al., *The vascular plants of British Columbia. Part I. Gymnosperms and dicotyledons (Aceraceae through Curcurbitaceae)*. Canadian Field-Naturalist 104: 620.

Cody, W. J. 1991a. Review of R. C. Barneby, *Fabales. Volume 3, Part B* of A. Cronquist et al., *Intermountain flora: vascular plants of the Intermountain West, U.S.A.* Canadian Field-Naturalist 105: 144.

Cody, W. J. 1991b. Review of I.-C. Chung, *Eastern North America as seen by a botanist: Pictorial I, the Arctic Region;* and *Pictorial II, the Wooded Regions*. Canadian Field-Naturalist 105: 144.

Cody, W. J. 1991c. Review of T. C. Brayshaw, *Buttercups, waterlilies, and their relatives: (the order Ranales) in British Columbia*. Canadian Field-Naturalist 105: 302.

Cody, W. J. 1992a. Review of J. T. Schofield, *Discovering wild plants, Alaska, western Canada, and the Northwest*. Canadian Field-Naturalist 106: 167.

Cody, W. J. 1992b. Review of T. C. Peattie, *A natural history of trees of eastern and central North America*, and T. C. Peattie, *A natural history of western trees*. Canadian Field-Naturalist 106: 415-416.

Cody, W. J. 1992c. Review of D. Isely, *Vascular flora of the southeastern United States. Volume 3, Part 2. Leguminosae (Fabaceae)*. Canadian Field-Naturalist 106: 416.

Cody, W. J. 1992d. Review of G. B. Ownbey and T. Morley, *Vascular plants of Minnesota, a checklist and atlas*. Canadian Field-Naturalist 106: 417.

Cody, W. J. 1992e. Review of C. Jermy and J. Camus, *The illustrated field guide to ferns and allied plants of the British Isles*. Canadian Field-Naturalist 106: 417.

Cody, W. J. 1992f. Review of H. A. Gleason and A. Cronquist, *Manual of vascular plants of northeastern United States and adjacent Canada*. Canadian Field-Naturalist 106: 417-418.

Cody, W. J. 1993a. Review of W. A. Weber and R. C. Wittmann, *Catalogue of the Colorado flora: a biodiversity baseline*. Canadian Field-Naturalist 107: 131.

Cody, W. J. 1993b. Review of A. MacKinnon, J. Pojar, and R. Coupé (editors), *Plants of northern British Columbia*. Canadian Field-Naturalist 107: 131-132.

Cody, W. J. 1994a. Review of R. D. Dorn, *Vascular plants of Wyoming*, second edition. Canadian Field-Naturalist 108: 125.

Cody, W. J. 1994b. Review of J. J. Schofield, *Alaska's wild plants: a guide to Alaska's edible harvest*. Canadian Field-Naturalist 108: 126.

Cody, W. J. 1994c. Review of J. De Santo, *Bitterroot*. Canadian Field-Naturalist 108: 126.

Cody, W. J. 1994d. Review of J. C. Hickman (editor), *The Jepson manual: higher plants of California*. Canadian Field-Naturalist 108: 128.

Cody, W. J. 1994e. Review of E. C. Pielou, *A naturalist's guide to the Arctic*. Canadian Field-Naturalist 108: 513.

Cody, W. J. 1994f. Review of A. Cronquist, *Intermountain flora: vascular plants of the Intermountain West, U.S.A. Volume 5. Asterales*. Canadian Field-Naturalist 108: 513-514.

Cody, W. J. 1994g. Review of S. L. Welsh et al., *A Utah flora*. Canadian Field-Naturalist 108: 514.

Cody, W. J. 1995a. Review of K. Budd and R. Careless (editors), *Tatshenshini River wild*. Canadian Field-Naturalist 109: 139-140.

Cody, W. J. 1995b. Horsetail. *In* The Canadian Encyclopedia, updated CD-ROM.

Cody, W. J. 1995c. Club-moss. *In* The Canadian Encyclopedia, updated CD-ROM.

Cody, W. J. 1995d. Fern. *In* the Canadian Encyclopedia, updated CD-ROM.

Cody, W. J. 1995e. Review of Flora of North America Editorial Committee, *Flora of North America north of Mexico. Volume 1. Introduction*. Canadian Field-Naturalist 109: 387-389.

Cody, W. J. 1995f. Review of Flora of North America Editorial Committee, *Flora of North America north of Mexico. Volume 2. Pteridophytes and gymnosperms*. Canadian Field-Naturalist 109: 390.

Cody, W. J. 1995g. Review of W. B. Zomlefer, *A guide to flowering plant families*. Canadian Field-Naturalist 109: 501-502.

Cody, W. J. 1995h. Review of L. Brako et al., *Scientific and common names of 7000 vascular plants in the United States*. Canadian Field-Naturalist 109: 504.

Cody, W. J. 1996a. Review of G. W. Douglas, *The sunflower family (Asteraceae) of British Columbia. Volume 2. Astereae, Anthemideae, Eupatorieae and Inuleae*. Canadian Field-Naturalist 110: 565.

Cody, W. J. 1996b. Review of Bruce-Grey Plant Committee, *A checklist of vascular plants for Bruce and Grey Counties*. Canadian Field-Naturalist 110: 721.

Cody, W. J. 1996c. Review of R. M. Turner et al., *Sonoran Desert plants: an ecological atlas*. Canadian Field-Naturalist 110: 721.

Cody, W. J. 1997. Review of D. Johnson et al., *Plants of the western boreal forest and aspen parkland*. Canadian Field-Naturalist 111: 697-698.

Cody, W. J. 1998a. Review of A. Crowder et al., *Plants of the Kingston region*. Canadian Field-Naturalist 112: 179.

Cody, W. J. 1998b. Review of R. W. Scott, *The alpine flora of the Rocky Mountains. Volume 1. The Middle Rockies*. Canadian Field-Naturalist 112: 182-183.

Cody, W. J. 1998c. Review of A. Cronquist et al., *Intermountain flora: vascular plants of the Intermountain West, U.S.A. Volume 3, Part A. Subclass Rosidae (except Fabales)*. Canadian Field-Naturalist 112: 183.

Cody, W. J. 1998d. Review of A. F. Tryon and R. C. Moran, *The ferns and allied plants of New England*. Canadian Field-Naturalist 112: 568.

Cody, W. J. 1998e. Review of R. S. Mitchell and G. C. Tucker, *Revised checklist of New York State plants*. Canadian Field-Naturalist 112: 568-569.

Cody, W. J. 1998f. Review of B. Hallworth and C. C. Chinnappa, *Plants of Kananaskis Country in the Rocky Mountains of Alberta*. Canadian Field-Naturalist 112: 570-571.

Cody, W. J. 1998g. Review of N. H. Holmgren, *Illustrated companion to Gleason and Cronquist's Manual: illustrations of the vascular plants of northeastern United States and adjacent Canada*. Canadian Field-Naturalist 112: 748.

Cody, W. J. 1999a. Review of R. P. Wunderlin, *Guide to the vascular plants of Florida*. Canadian Field-Naturalist 113: 547.

Cody, W. J. 1999b. Review of S. G. Newmaster et al., *Ontario plant list*. Canadian Field-Naturalist 113: 703.

Cody, W. J. 1999c. Review of H. Qian and K. Klinka, *Plants of British Columbia, scientific and common names of vascular plants, bryophytes and lichens*. Canadian Field-Naturalist 113: 704.

Cody, W. J. 1999e. Review of A. Haines and T. F. Vining, *Flora of Maine: a manual for identification of native and naturalized vascular plants of Maine*. Canadian Field-Naturalist 113: 704-705.

Cody, W. J. 1999e. Review of G. W. Douglas et al., *Rare native plants of British Columbia*. Canadian Field-Naturalist 113: 706.

Cody, W. J. 2000a. Review of G. M. Diggs Jr. et al., *Shinners & Mahler's Illustrated flora of north central Texas*. Canadian Field-Naturalist 114: 170.

Cody, W. J. 2000b. Review of R. K. Rabeler, *Gleason's Plants of Michigan: a field guide*. Canadian Field-Naturalist 114: 171.

Cody, W. J. 2000c. Review of the Bruce-Grey Plant Committee, *A guide to the ferns of Grey and Bruce Counties, Ontario*. Canadian Field-Naturalist 114: 345.

Cody, W. J. 2000d. Review of S. S. Talbot et al., *Atlas of endemic vascular plants of the Arctic*. Canadian Field-Naturalist 114: 720-721.

Cody, W. J. 2000e. Review of G. A. Petrides, *Trees of the Pacific Northwest*. Canadian Field-Naturalist 114: 721.

Cody, W. J. 2001a. Review of H. R. Hinds, *Flora of New Brunswick*, second edition. Canadian Field-Naturalist 115: 718.

Cody, W. J. 2001b. Review of R. P. Wunderlin and B. F. Hansen, *Flora of Florida. Volume 1. Pteridophytes and gymnosperms*. Canadian Field-Naturalist 115: 718-719.

Cody, W. J. 2001c. Review of D. Bick, *Flora of Mount Rainier National Park*. Canadian Field-Naturalist 115: 720.

Cody, W. J. 2001d. Review of J. K. Morton and J. M. Venn, *The Flora of Manitoulan* [sic] *Island and the adjacent islands of Lake Huron, Georgian Bay and the North Channel*, third edition. Canadian Field-Naturalist 115: 721.

Cody, W. J. 2002a. Review of D. G. Frodin, *Guide to standard floras of the world: an annotated geographically arranged systematic bibliography of the principal floras, enumerations, checklists, and chorological atlases of different areas*, second edition. Canadian Field-Naturalist 116: 168.

Cody, W. J. 2002b. Review of L. Kershaw et al., *Rare vascular plants of Alberta*. Canadian Field-Naturalist 116: 344-345.

Cody, W. J. 2002c. Review of G. W. Douglas, D. Meidinger, and J. L. Penny, *Rare native vascular plants of British Columbia*, second edition. Canadian Field-Naturalist 116: 670.

Cody, W. J. 2002d. Review of G. Lamoureux and R. Larose, *Flore printanière*. Canadian Field-Naturalist 116: 670-671.

Cody, W. J. 2003a. Review of G. W. Douglas et al., *Illustrated flora of British Columbia,* Volumes 1-8. Canadian Field-Naturalist 117: 329.

Cody, W. J. 2003b. Review of L. Kershaw, *Ontario wild flowers*. Canadian Field-Naturalist 117: 330.

Cody, W. J. 2003c. Review of D. More and J. White, *The illustrated encyclopedia of trees*. Canadian Field-Naturalist 117: 496.

Cody, W. J. 2003d. Review of D. E. Schnell, *Carnivorous plants of the United States and Canada*, second edition. Canadian Field-Naturalist 117: 496-497.

Cody, W. J. 2003e. Review of J. L. Riley, *Flora of the Hudson Bay Lowland and its postglacial origins*. Canadian Field-Naturalist 117: 669-670.

Cody, W. J. 2004a. Review of H. A. Gleason and A. Cronquist, *Manual of vascular plants of northeastern United States and adjacent Canada,* second edition. Canadian Field-Naturalist 118: 147.

Cody, W. J. 2004b. Review of J. G. Trelawny, *Wild flowers of the Yukon, Alaska and northwestern Canada*, 2nd edition. Canadian Field-Naturalist 118: 289.

Cody, W. J. 2004c. Review of L. J. Clark, *Wild flowers of field & slope in the Pacific Northwest, Wild flowers of forest & woodland in the Pacific Northwest*, and *Wild flowers of the mountains in the Pacific Northwest*. Canadian Field-Naturalist 118: 289. Re-issued. Canadian Field-Naturalist 118: 476.

Cody, W. J. 2004d. Review of L. W. Clark, edited by J. G. Trelawny, *Lewis Clark's field guide to wildflowers of the sea coast in the Pacific Northwest*. Canadian Field-Naturalist 118: 476.

Cody, W. J. 2005a. Review of M. Blondeau, C. Roy, and A. Cuerrier, *Atlas des plantes des villages du Nunavik. – Atlas of the plants of the Nunavik villages*. Canadian Field-Naturalist 119: 150.

Cody, W. J. 2005b. Review of D. Ames et al., *Orchids of Manitoba*. Canadian Field-Naturalist 119: 463.

Appendix Table 3. New taxa and new combinations published by W. J. Cody with reference, including taxa described or transferred by other botanists in Bill's papers. Specimen citations are included for the new names. All holotypes are at DAO.

Adiantum pedatum L. ssp. ***calderi*** Cody, Rhodora 85: 93-94. 1983. CANADA: Quebec, Gaspé Co., Mt. Albert, *Collins & Fernald s.n.*, 14 August 1905.

Androsace chamaejasme Host var. ***lehmanniana*** (Sprengel) Boivin in Cody, Canadian Field-Naturalist 68(3): 116. 1954.

Antennaria leontopodioides Cody, Canadian Field-Naturalist 70: 127. 1957. CANADA: District of Mackenzie, Indin Lake, 64°17'N, 115°12'W, *Cody & McCanse 3473*, 12 August 1949.

Aster nahanniensis Cody in Scotter & Cody, Le Naturaliste canadien 101: 888. 1974. CANADA: District of Mackenzie, South Nahanni River area, 61°31'30"N, 126°29'W, *G. W. Scotter 17412*, 16 September 1971.

Aster sibiricus L. var. ***pygmaeus*** (Lindley) Cody, Canadian Field-Naturalist 68(3): 117. 1954.

Botrychium virginianum (L.) Sw. var. ***europaeum*** Angstrom f. ***heterodoxum*** Cody, American Fern Journal 51: 36. 1961. CANADA: Saskatchewan, McKague, *A.J. Breitung s.n.*, 25 June 1935.

Botrychium virginianum (L.) Sw. var. ***virginianum*** f. ***anomalum*** Cody, American Fern Journal 51: 36. 1961. CANADA: Ontario, Renfrew Co., 2 ½ miles west of Braeside, *Cody & Dore 11133*, 19 June 1959.

Braya glabella Richardson ssp. ***purpurascens*** (R. Brown) Cody, Canadian Field-Naturalist 108(1): 93. 1994.

Cardamine oligosperma Nutt. ssp. ***kamtschatica*** (Regel) Cody, Canadian Field-Naturalist 108(1): 93. 1994.

Cardamine purpurea Cham. & Schlecht. f. ***albiflora*** (Hultén) Cody, Canadian Field-Naturalist 108(1): 93. 1994.

Dryopteris disjuncta (Ledeb.) C.V. Morton f. ***glandulosa*** (Tryon) Cody, American Fern Journal 45: 126. 1955.

Elymus trachycaulus (Link) Gould ex Shiners ssp. ***glaucus*** (Pease & A.H. Moore) Cody, Canadian Field-Naturalist 108(1): 93. 1994.

Gentianella amarella (L.) Börner ssp. ***acuta*** (Michx.) J. M. Gillett f. ***albescens*** (Lepage) Cody, Canadian Field-Naturalist 108(1): 94. 1994.

Haplopappus lanceolatus (Hook.) T.& G. var. ***sublanatus*** Cody, Canadian Field.-Naturalist 70: 126. 1957. CANADA: District of Mackenzie, salt plain W of Fort Smith, 60°03'N 112°25'W, *Cody & Loan 4576*, 20 July 1950.

Hedysarum alpinum L. f. ***albiflorum*** (Standley) Cody, Canadian Field-Naturalist 108(1): 94. 1994.

Hedysarum boreale Nutt. subsp. ***mackenziei*** (Richards.) Welsh f. ***niveum*** (Boivin) Cody, Canadian Field-Naturalist 108(1): 94. 1994.

Lagotis glauca Gaertn. ssp. ***minor*** (Willd.) Hultén f. ***albiflora*** Cody, Canadian Field-Naturalist 108: 94. 1994. CANADA: Yukon, Ogilvie Mountains, 7 miles South of Tombstone Mountain, 64°18'N, 138°38'W, *Cody & Ginns 34664*, 16 July 1984.

Lilium canadense L. ssp. ***michiganense*** (Farwell) B. Boivin & Cody, Rhodora 58(685): 17. 1956.

Lilium canadense L. ssp. ***michiganense*** (Farwell) B. Boivin & Cody f. ***peramoenum*** (Farwell) B. Boivin & Cody, Rhodora 58(685): 18. 1956.

Lilium canadense L. ssp. ***michiganense*** (Farwell) B. Boivin & Cody f. ***uniflorum*** (Farwell) B. Boivin & Cody, Rhodora 58(685): 18. 1956.

Lilium canadense L. ssp. ***superbum*** (L.) B. Boivin & Cody, Rhodora 58(685): 19. 1956.

Lupinus arcticus S. Wats. f. ***albus*** Cody, Canadian Field-Naturalist 108(1): 94. 1994. CANADA: Yukon Territory, Richardson Mountains, S end of Skull Range, 68°28'N, 137°27'W, *Cody & Ginns 31629*, 12 July 1982.

Lychnis apetala L. var. ***arctica*** (Fries) Cody, Canadian Field-Naturalist 67(1): 41. 1953.

Lychnis apetala L. var. ***arctica*** (Fries) Cody f. ***palea*** (Pal.) Cody, Canadian Field-Naturalist 67(1): 41. 1953.

Myosotis alpestris F.W. Schmidt ssp. ***asiatica*** Vestergr. ex Hultén f. ***eyerdamii*** (B. Boivin) Cody, Canadian Field-Naturalist 108(1): 94. 1994.

Nasturtium crystallinum (Rollins) G. Mulligan in G. A. Mulligan & W. J. Cody, Canadian Field-Naturalist 109(1): 111. 1995.

Oxytropis campestris (L.) DC. ssp. ***roaldii*** (Ostenf.) Cody, Canadian Field-Naturalist 108(1): 94. 1994.

Oxytropis campestris (L.) DC. ssp. ***varians*** (Rydb.) Cody, Canadian Field-Naturalist 108(1): 94. 1994.

Oxytropis deflexa (Pall.) DC. ssp. ***foliolosa*** (Hook.) Cody, Canadian Field-Naturalist 108(1): 94. 1994.

Oxytropis deflexa (Pall.) DC. ssp. ***sericea*** (T. & G.) Cody, Canadian Field-Naturalist 108(1): 94. 1994.

Oxytropis nigrescens (Pall.) Fisch. ssp. ***lonchopoda*** (Barneby) Cody, Canadian Field-Naturalist 108(1): 94. 1994.

Oxytropis sericea Nutt. ssp. ***spicata*** (Hook.) Cody, Canadian Field-Naturalist 108(1): 94. 1994.

Parrya arctica R.Br. f. ***albiflora*** Boivin in Cody, Canadian Field-Naturalist 67: 42. 1953. CANADA: District of Franklin, Cambridge Bay, *Sweatman & Smith 6*, 2 July 1950.

Parrya nudicaulis (L.) Regel f. ***albiflora*** Cody, Canadian Field-Naturalist 108(1): 94. 1994. CANADA: Yukon Territory, hills 15 miles S of Dawson, 63°55'N, 139°28'W, elevation 3800', *Cody & Ginns 33444*, 5 July 1984.

Pedicularis lanata Cham. & Schlecht. f. ***alba*** Cody, Canadian Field-Naturalist 65(4): 143. 1951. CANADA: District of Keewatin, Southampton Island near Kirchoffer R., *W. J. Cody 1146*, 3 July 1948.

Pedicularis sudetica Willd. f. ***alba*** Cody, Canadian Field-Naturalist 65(4): 143. 1951. CANADA: District of Keewatin, Southampton Island, Coral Harbour, *W. J. Cody 1352A*, 16 July 1948.

Pellaea glabella Mett. ex Kuhn var. ***nana*** (Richardson) Cody, Canadian Field-Naturalist 77(2) 109. 1963.

Petasites frigidus (L.) Fr. ssp. ***arcticus*** (Porsild) Cody, Canadian Field-Naturalist 108(1): 94. 1994.

Petasites frigidus (L.) Fr. ssp. ***nivalis*** (Greene) Cody, Canadian Field-Naturalist 108(1): 94. 1994.

Petasites frigidus (L.) Fr. ssp. ***palmatus*** (Aiton) Cody, Canadian Field-Naturalist 108(1): 94. 1994.

Polemonium boreale Adams f. ***albiflorum*** Cody, Canadian Field-Naturalist 117: 462. 2003. CANADA: Mackenzie, Horton River, 69°42'N, 126°56'W, *G. W. Scotter 10101b*, 6 July 1995.

Polystichum ×hagenahii Cody, American Fern Journal 58: 30. 1968. CANADA: Ontario, Bruce Co., Cape Crocker Indian Reservation, *Wagner & Hagenah s.n.*, 1953.

Primula borealis Duby f. ***albiflora*** Cody, Canadian Field-Naturalist 79: 105. 1965. CANADA: District of Mackenzie, Anderson River Delta, 69°42'N, 129°00'W, *T. W. Barry 290*, 27 June 1962.

Saussurea angustifolia (Willd.) DC. ssp. ***yukonesnis*** (Porsild) Cody, Canadian Field-Naturalist 108(1): 95. 1994.

Saxifraga bronchialis L. ssp. ***codyana*** (Zhmylev) Cody, Canadian Field-Naturalist 108(1): 94. 1994.

Saxifraga tricuspidata Rottb. f. ***woodruffii*** Calder in Cody, Canadian Field-Naturalist 64: 92. 1950. CANADA: District of Franklin, Melville Peninsula, Committee Bay, *Woodruff 38*, 20 August 1948.

Silene acaulis L. ssp. ***subacaulescens*** (F.N. Williams) Hultén f. ***albiflora*** Cody, Canadian Field-Naturalist 108(1): 94. 1994. CANADA: Yukon Territory, km 21, Upper Sheep Creek Rd. off km 154 Canol Rd., elevation 5800', *Hodgson 1421A*, 27 July 1984.

Silene acaulis L. var. ***albiflora*** Cody, Canadian Field-Naturalist 70: 127. 1957 [not there and not found]

Smelowskia borealis (Greene) Drury & Rollins ssp. ***jordalii*** (Drury & Rollins) Cody, Canadian Field-Naturalist 108(1): 94.

Thalictrum sparsiflorum Turcz. ssp. ***richardsonii*** (Gray) Cody, Canadian Field-Naturalist 108(1): 93. 1994.

Veronica wormskjoldii R. & S. f. ***albiflora*** Cody, Canadian Field-Naturalist 108(1): 94. 1994. CANADA: Yukon Territory, Dempster Highway, km 80, *G. Brunner s.n.*, 3 August 1990.

Received February 2010
Accepted 16 May 2010

News and Comment

William O. Pruitt 1922-2009

Dr. William ("Bill") O. Pruitt, Jr., age 87, died 7 December 2009. Dr. Pruitt served as Associate Editor of *The Canadian Field-Naturalist* 1971-76, 1979-2010, and was actively reviewing manuscripts until a few months before the end of the later year. He had taught biology at University of Alaska in Fairbanks, Memorial University of Newfoundland, and the University of Manitoba. He was a Senior Scholar at the Department of Biological Sciences at the latter institution at the time of his death. He is survived by his wife of 58 years, Edna (Nauert), daughter, Cheryl Pruitt (Mick), and son, Charles Pruitt. Dr. Pruitt founded the Taiga Biological Station in northeastern Manitoba in 1973 to provide field training, with emphasis boreal ecology. Among many honors he received was the Canadian government's Northern Science Award Centenary Medal "for significant contribution to understanding of the North." (See 1989 *The Canadian Field-Naturalist* 103(4): 605-609 for presentation and address). A full tribute and bibliography is in preparation.

Canadian Directory of Expertise in Wildlife Health, Second edition

This 2009 publication was produced by the Canadian Cooperative Wildlife Heath Centre, Saskatoon, Saskatchewan. Its introduction explains that was compiled to fill a perceived need to bring together a guide to the expertise and information related to wildlife health which is scattered in Canada. Nineteen pages of tables list authorities by discipline, by vertebrate group, and by etiologic agents (parasites, bacteria, other), and forensic identification. These are followed by a concluding 31 pages listing contact information and field(s) of interest for each of the authorities listed in the tables.

Hubert Norman MacKenzie, 1922 – 2009

Honorary Member and Past President of the Ottawa Field-Naturalists' Club died in retirement in South Surry, Vancouver, British Columbia, 9 December 2009. A tribute is in preparation by Dan Brunton will appear in a future issue.

Advice for Contributors to *The Canadian Field-Naturalist*

Content

The Canadian Field-Naturalist is a medium for the publication of scientific papers by amateur and professional naturalists or field biologists reporting observations and results of investigations in any field of natural history provided that they are original, significant, and relevant to Canada. All readers and other potential contributors are invited to submit for consideration their manuscripts meeting these criteria. The journal also publishes natural history news and comment items if judged by the Editor to be of interest to readers and subscribers, and book reviews. Please correspond with the Book Review Editor concerning suitability of manuscripts for this section. For further information consult: A Publication Policy for the Ottawa Field-Naturalists' Club, 1983. *The Canadian Field-Naturalist* 97(2): 231-234. Potential contributors who are neither members of *The Ottawa Field-Naturalists' Club* nor subscribers to *The Canadian Field-Naturalist* are encouraged to support the journal by becoming either members or subscribers.

Manuscripts

Submit by e-mail or post **to the Editor,** in either English or French, one complete manuscript **written in the journal style**. The research reported should be original. It is recommended that authors ask qualified persons to appraise the paper before it is submitted. All authors should have read and approved it. Institutional or contract approval for the publication of the data must have been obtained by the authors. Also authors are expected to have complied with all pertinent legislation regarding the study, disturbance, or collection of animals, plants or minerals. The place where voucher specimens have been deposited, and their catalogue numbers, should be given. Latitude and longitude should be included for all individual localities where collections or observations have been made.

Manuscripts should be formatted for standard-size paper, **doublespaced throughout,** generous margins to allow for copy marking, and **each page numbered.** For Articles and Notes provide a citation strip, an abstract, and a list of key words. Generally, words should not be abbreviated but use SI symbols for units of measure. The names of authors of scientific names may be omitted except in taxonomic manuscripts or other papers involving nomenclatural problems. "Standard" common names (with initial letters capitalized) should be used at least once for all species of higher animals and plants; all should also be identified by scientific name.

The names of journals in the Literature Cited should be written out in full. Unpublished reports and web documents should not be cited here but placed in a separate Documents Cited section. List the captions for figures numbered in arabic numerals and typed together on a separate page. Present the tables each titled, numbered consecutively in arabic numerals, and placed on a separate page.

Be certain to check that all text citations are included either in the *Documents Cited* (for unpublished reports, manuscripts and web pages) indicated in text with an * after date or *Literature Cited* for published/printed and widely circulated books and papers).

Check recent issues (particularly Literature Cited) for journal format. Either "Canadian" or "American" spellings are acceptable in English but should be consistent within one manuscript. **The Oxford English Dictionary, Webster's New International Dictionary** and le **Grand Larousse Encyclopédique** are the authorities for spelling.

Illustrations

Electronic versions of photographs should be high resolution. Photographic reproduction of line drawings should be no larger than a standard page.

Reviewing Policy

Manuscripts submitted to *The Canadian Field-Naturalist* are normally sent for evaluation to an Associate Editor (who reviews it or asks another qualified person to do so), and at least one other reviewer, who is a specialist in the field, chosen by the Editor. Authors are encouraged to suggest names of suitable referees. Reviewers are asked to give a general appraisal of the manuscript followed by specific comments and constructive recommendations. Almost all manuscripts accepted for publication have undergone revision—sometimes extensive revision and reappraisal. **The Editor makes the final decision** on whether a manuscript is acceptable for publication, and in so doing aims to maintain the scientific quality, content, overall high standards and consistency of style, of the journal.

Special Charges — Please take note

Authors **must share in the cost of publication** by paying $90 for each page, plus $30 for each illustration (any size up to a full page), and up to $90 per page for tables (depending on size). Authors may also be charged for their changes in proofs. Reproduction of color photos is extremely expensive; price quotations may be obtained from the Editor.

Limited journal funds are available to help offset publication charges to authors without grants or institutional support. Requests for financial assistance should be made to the Editor when the manuscript is submitted and noted when the galley is returned .

Reprints

An order form for the purchase of reprints or pdf will accompany the galley proofs sent to the authors. Invoices for publication costs will be sent when the submission is published.

FRANCIS R. COOK, Editor
RR 3 North Augusta, Ontario K0G 1R0 Canada

ailing date of the previous issue 123(4): 11 April 2011

Articles

Notes

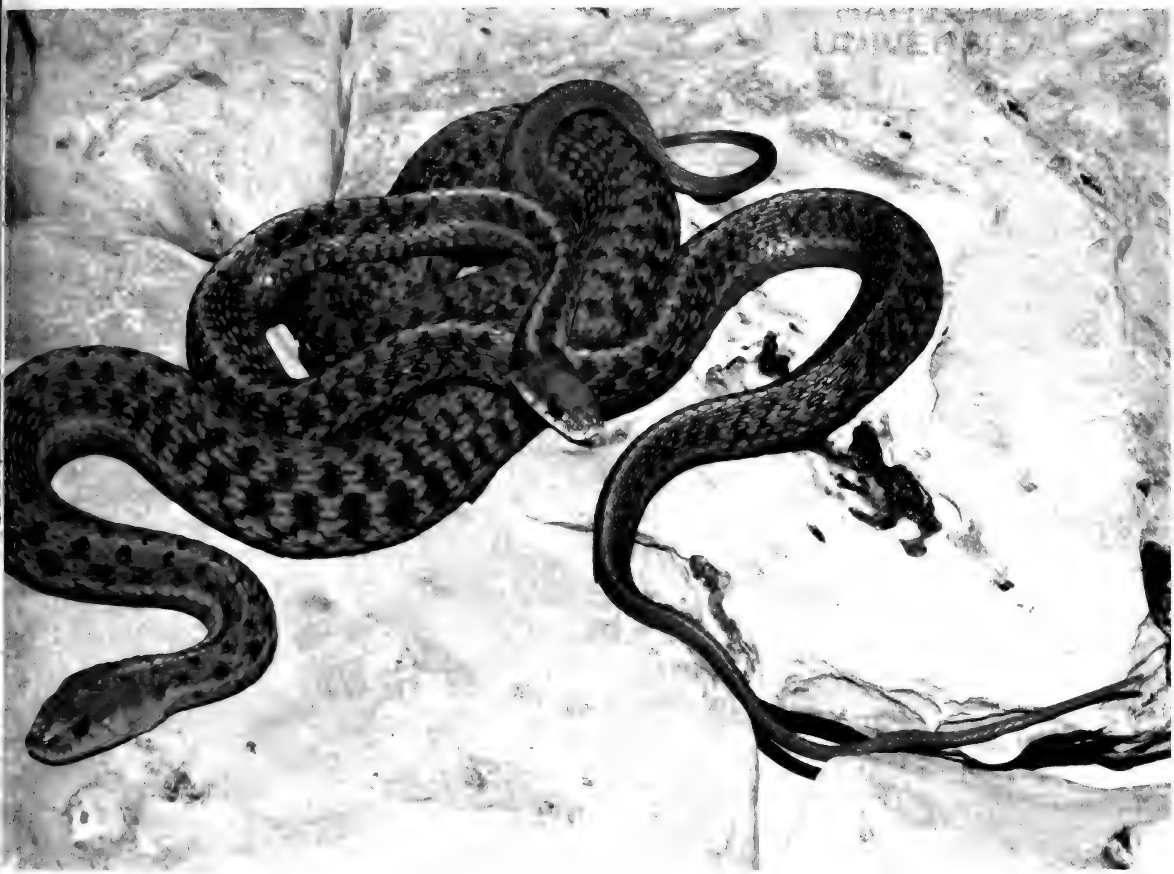
Book Reviews

(continued on inside back cov

ISSN 0008-3550

The CANADIAN FIELD-NATURALIST

Published by THE OTTAWA FIELD-NATURALISTS' CLUB, Ottawa, Canada



Volume 124, Number 2 April–June 2010

The Canadian Field-Naturalist

The *Canadian Field-Naturalist* is published quarterly by The Ottawa Field-Naturalists' Club. Opinions and ideas expressed in this journal do not necessarily reflect those of The Ottawa Field-Naturalists' Club or any other agency.

Editor: Dr. Francis R. Cook, R.R. 3, North Augusta, Ontario K0G 1R0; (613) 269-3211; e-mail: cfn@ofnc.ca
Copy Editor: Elizabeth Morton
Business Manager: Frank Pope, P.O. Box 35069, Westgate P.O. Ottawa, Canada K1Z 1A2
Book-review Editor: Roy John, 2193 Emard Crescent, Ottawa, Ontario K1J 6K5, e-mail: r.john@rogers.ca

Associate Editors: Robert R. Anderson, Warren B. Ballard, Charles D. Bird, Robert R. Campbell, Paul M. Catling, Brian W. Coad, Anthony J. Erskine, David Nagorsen, Donald F. McAlpine

Chairman, Publications Committee: Ronald E. Bedford

All manuscripts intended for publication except Book Reviews should be addressed to the Editor and sent by e-mail (attached) or postal mail (with disk).

Book-review correspondence should be sent by e-mail or postal mail to Roy John, Book-review Editor.

Subscriptions and Membership
Subscription rates for individuals are $33 per calendar year. Libraries and other institutions may subscribe at the rate of $50 per year (volume). The Ottawa Field-Naturalists' Club annual membership fee of $33 (individual) $35 (family) $50 (sustaining) and $500 (life) includes a subscription to *The Canadian Field-Naturalist*. All foreign subscribers and members (including USA) must add an additional $5.00 to cover postage. The club regional journal, *Trail & Landscape*, covers the Ottawa District and Local Club events. It is mailed to Ottawa area members, and available to those outside Ottawa on request. It is available to Libraries at $33 per year. Subscriptions, applications for membership, notices of changes of address, and undeliverable copies should be mailed to: The Ottawa Field-Naturalists Club, P.O. Box 35069, Westgate P.O. Ottawa, Canada K1Z 1A2. Canada Post Publications Mail Agreement number 40012317. Return Postage Guaranteed. Date of this issue: April – June 2010 (April 2011).

COVER: Two erythristic adult female Maritime Garter Snakes (*Thamnophis sirtalis pallidulus*) collected from mainland Nova Scotia, Canada. See article by John Gilhen pages 99-103.

The Canadian Field-Naturalist

Volume 124, Number 2 April–June 2010

Erythrism in the Maritime Garter Snake, *Thamnophis sirtalis pallidulus*, in Nova Scotia

JOHN GILHEN

Nova Scotia Museum of Natural History, 1747 Summer Street, Halifax, Nova Scotia B3H 3A6 Canada; e-mail: gilhenja@gov.ns.ca

Gilhen, John. 2010. Erythrism in the Maritime Garter Snake, *Thamnophis sirtalis pallidulus*, in Nova Scotia. Canadian Field-Naturalist 124(2): 99–103.

The Maritime Garter Snake, *Thamnophis sirtalis pallidulus*, is highly variable in pattern and colour. Although this subspecies is largely defined on the basis of colour, four colour morphs have previously been described for the subspecies, including a melanistic form. Based on specimens from Nova Scotia, Canada, a fifth, uncommon erythristic variant is added to the complex colour variation known for the Maritime Garter Snake.

Key Words: Maritime Garter Snake, *Thamnophis sirtalis pallidulus*, erythrism, erythristic, ground colour, scarlet, northern mainland, Nova Scotia, Canada.

In his re-description of the Maritime Garter Snake, *Thamnophis sirtalis pallidulus*, Bleakney (1959) noted that the snakes of the genus *Thamnophis* are notoriously plastic in colour characters. Colour variation in the genus may be consistent and confined to a limited geographic region or a number of colour phases may occur in one area. In the Maritime Garter Snake, the colour shade often varies from light anteriorly to darker posteriorly. This plasticity in shade or colour intensity is further complicated in that it is influenced by the time before or after a snake has shed its skin. Rossman et al. (1996) also note that the dorsal colour pattern in *T. sirtalis* is the most variable of any species in the genus, although where geographically consistent it has been used to define the 11 subspecies currently recognized within *T. sirtalis*. While comparing the *T. s. pallidulus* with its close relative the Eastern Garter Snake, *T. s. sirtalis*, Bleakney (1959) examined 376 specimens of the former and identified three patterns of colouration [Bleakney (1959) follows Ridgeway (1912) for colour descriptors]:

1. A cinnamon-brown ground colour, cinnamon-buff lateral stripes, and with ventral scales colonial-buff anteriorly and olive-buff posteriorly;
2. Yellowish-olive ground colour, with chamois colour lateral stripes and with ventral scales changing from amber-yellow anteriorly to tea-green posteriorly;
3. Olive-grey ground colour with greyish lateral stripes and with olive-buff to French-grey ventral scales.

The ground colour is broken on each side by two rows of alternating spots composed of groups of two to four scales which are hazel in colour with black margins. Futhermore, he found that approximately one third have a well defined gull-grey dorsal stripe, one-third have a short poorly delimited olive-yellow stripe, and the remaining one-third have no stripe at all.

Gilhen (1984) reported a fourth uncommon melanistic condition having a ground colour of black. I add an uncommon fifth condition which is distinctly scarlet in ground colour, or erythristic (Figure 1). Two adult female Maritime Garter Snakes which strikingly manifest erythrism were captured in Nova Scotia (Cover). The first one collected at Indian Brook IR 14, Hants County (45°05'00"N, 63°30'00"W), in August 2005 is approximately 72 centimeters in total length. The second was collected at West St. Andrews, Colchester County (45°06'00"N, 63°18'00"W), on 7 July 2009 and is approximately 77 cm in total length.

Both females are scarlet in ground colour (Table 1). With the overall colouration including a complex and subtle mix of orange and red that blend with the scarlet ground colour. The Indian Brook female has a distinct dorsal stripe. The West St. Andrews female has a delimited dorsal stripe which becomes darker and interrupted along its length by the top row of spots. The apparent rarity of this colour morph in Nova Scotia warrants a general description, which are provided here for both females. Since the body colour of Maritime Garter Snakes appear to be lighter anteriorly, becoming darker posteriorly, the detailed description of the erythristic specimens that follow include the head, about five centimeters of the mid section of the

trunk and the anterior tail. Colour name and number are after Smithe (1975). The colour number is given where it first appears in the text and in Table 1.

Erythristic adult female from Indian Brook

From a distance, the ground colour is Scarlet (14). This snake (Cover and Table 1) has a contrasting Buff-Yellow (53) dorsal stripe, a thin Flame Scarlet (15) lateral stripe on the second row of dorsal scales on both sides, and two alternating rows of Burnt-Umber (22) square-shaped spots in a checkerboard pattern between the stripes. The top row of spots is slightly invasive of the dorsal stripe but does not completely interrupt the stripe anywhere along its length. The skin between the scales where the spots occur is Blackish Neutral Gray (82) and where there are no spots the skin is Geranium Pink (13).

The top of the head is Chrome Orange (16). The sides of the head covering the labials are glossy Cream Color (54). The pupils of the eyes are Sepia (119) with a Chrome Orange (16) iris. The underside of the head, and approximately one third of the anterior underside of the trunk, are Cream Color. The ventral scales anteriorly are bordered in Maroon (31), becoming darker Maroon on the remainder of the underside of the trunk and tail. The Hazel (35) spot on both sides of each ventral scale are obscured by the previous overlapping ventral scale. The tail is dark Scarlet above and dark Maroon on the underside.(Figure 2).

Erythristic adult female from West St. Andrews

From a distance the ground colour is Scarlet. It has a brief contrasting Buff-Yellow dorsal stripe which becomes darker and delimiting along its length, a thin bright Geranium (12) lateral stripe on the second dorsal scale row on both sides, and two rows of Chestnut (32) spots between the stripes. The top row of square-shaped spots are much smaller than the large, rectangular, bottom row of spots. The top row of spots overlap the midline of the back. The skin between the scales where spots occur is Blackish Neutral Gray and where there are no spots Geranium-Pink.

The top of the head is Crome Orange. The sides of the head covering the labials are a glossy Spectrum-Orange (17). The pupil of the eyes are Sepia with a Chrome Orange iris. With the exception of the chin, which is Cream in color, the remaining underside of the head and anterior one third of the trunk is glossy Spectrum-Orange bordered in Geranium. The underside is dappled with Geranium on Spectrum Orange. This individual has a Hazel spot highlighted in Orange Yellow (18) on both sides of the ventral scales. The tail is dark Scarlet above and dark Geranium on the underside.

Discussion

Webster's Dictionary defines erythrism as a condition marked by exceptional prevalence of red pigmentation (as in skin or hair) (Merriam 1967). Erythrism in the *T. s. pallidulus* represents an uncommon but naturally occuring colour condition found mostly in northern mainland Nova Scotia (Figure 3). Erythrism occurs in various shades and degrees of intensity but has not been previously reported in the Maritime Garter Snake in the Maritime Provinces of Canada (Jones 1865; Gilpin 1875; Bleakney 1958; Cook 1967; and Gilhen 1984). J. Sherman Bleakney, Francis R. Cook and John Gilhen have observed the Maritime Garter Snake in Nova Scotia, combined for more than 60 years. Some individuals with orange or red skin between the scales have been reported from New Brunswick (Cox 1907), Prince Edward Island (Cook 1967) and in *Thamnophis sitalis sitalis* in Ontario (Logier 1939). In Quebec (Desroches and Rodrigue 2004) and Ontario (Logier 1939) individuals with red

FIGURE 1. Erythristic adult female Maritime Garter Snake, *Thamnophis sirtalis pallidulus*, captured at West St. Andrews, Colchester County, Nova Scotia, on 7 July 2009.

TABLE 1. Colour variation in two erythristic Maritime Garter Snakes (*Thamnophis sirtalis pallidulus*) from Nova Scotia. Colour descriptors with numbers in parentheses follow Smithe (1975).

Specimen Location:		Indian Brook	West St. Andrews
Ground Color:		Scarlet (14)	Scarlet
Head:	Above	Crome Orange (16)	Crome Orange
	Supralabials	Cream Color (54)	Spectrum Orange (17)
	Underside		
	Infralabials	Cream Color	Spectrum Orange
	Chin	Cream Color	Cream Color
Eyes:	Pupil	Blackish Neutral Gray (82)	Blackish Neutral Gray
Eyes:	Iris	Crome Orange	Crome Orange
Tongue:	Fork	Black: Scarlet	Black: Scarlet
Trunk:	Above Scarlet with		
	Dorsal Stripe	Buff-Yellow (53)	N/A
	Lateral Stripes	Flame Scarlet (15)	Geranium (12)
Spots	Burnt Umber (22)	Chestnut (32)	
Skin:	Between dorsal scales.		
	Where there are Spots	Blackish Neutral Gray (82)	Blackish Neutral Gray
	Where there are no Spots	Geranium Pink (13)	Geranium Pink
Underside:	Ventral Scales	Maroon (31)	Geranium
	Ventral Scale Side Spots	Hazel (35)	Hazel, highlighted in Orange Yellow (18)
Anal Plate:		Maroon	Geranium
	Subcaudal Scales	Maroon	Geranium
Tail:	Above	Scarlet	Scarlet
	Underside	Maroon	Geranium

FIGURE 2. Underside of erytheristic Martitime Garter Snake from Indian Brook IR 14, Hants County, Nova Scotia.

rather than yellow lateral stripes have been reported, and from Manitoba to British Columbia western subspecies of *Thamnophis sirtalis* have of red lateral barring on scales and skin which increases in extent to the west (Cook 1984; Rossman et al. 1996). None matches the overall erytherism reported here.

It was not until the late 1980s that I observed orange-brown individuals that would be considered approaching erythrism or part-erythristic.

In July 1989, while visiting Georges Island, Halifax Harbour, Halifax County, Nova Scotia, I noted that not only were Maritime Garter Snakes very common but

the variation in colour and pattern was exceptionally high for such a small (five hectare) drumlin landscape. There were four different adult individuals under one board. One brown male had orange ventral scales, posteriorly, as well as the anal plate and sub-caudal scales. Brown individuals with orange ventral and sub-caudal scales were also observed on Georges Island in 1993 by Suzanne Barnes (Barnes 1994 and Barnes et al 2006).

On 21 August 1993, I was asked to investigate a snake home invasion by snakes in Sunnybrae, Pictou County, Nova Scotia. It became obvious, from two freshly killed snakes near the front door, the species involved was the Maritime Garter Snake. Both snakes were orange- brown above with bright orange posterior ventral scales, anal plate, and sub-caudal scales. On the underside, the chin and labials were yellowish-orange. Each ventral scale anteriorly was yellowish-grey bordered in orange. The author considered both of these snakes more approaching erythrism than the Georges Island individual.

In the summer of 2004 Robert March photographed an adult orange-brown Maritime Garter Snake with a Buff Yellow dorsal stripe at Crescent Beach, Lunenburg County, Nova Scotia the colour photograph is on file at the Nova Scotia Museum of Natural History. This individual may be part-erythristic but the colour of the underside is not known. During May and June 2008 Jody MacKenzie and the author observed a number of Maritime Garter Snakes that were orange-brown in colour near a pond in a Stellarton wetland, Pictou County, Nova Scotia. The general colour was bright orange-brown. The ventral scales were yellowish-grey bordered in orange. The sub-caudal scales were uniform orange. A few individuals were photographed by Jody MacKenzie. These images are on file at the Nova Scotia Museum of Natural History. On 10 August 2008 Derek Bridgehouse photographed an adult female Maritime Garter Snake catching and eating an Eastern American Toad, *Anaxyrus a. americanus*, and he provided the image to the author for Nova Scotia Museum of Natural History records. This snake was also orange-brown above but the underside was not noted.

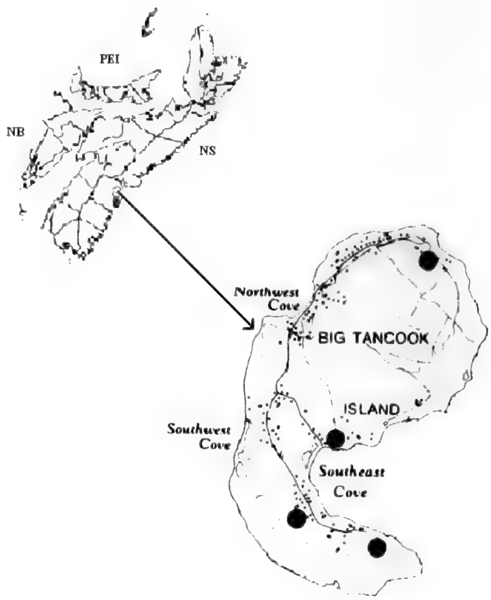


FIGURE 3. Distribution of erythristic Maritime Garter Snakes (*Thamnophis sirtalis pallidulus*), in Nova Scotia: Closed circles represent localities where two erythristic adult females were captured. Closed squares represent localities where part-erythristic individuals were captured. Open squares represent localities where only the dorsal colour patterns of two part-erythristic individuals were documented.

Acknowledgments

I am indebted to Andrew Hebda, Curator of Zoology, Nova Scotia Museum of Natural History, and Francis R. Cook reviewed the draft manuscript and I value their useful comments and suggestions. I am pleased to acknowledge Michael W. McDonald, Indian Brook, Nova Scotia, who provided the erythristic striped female from Indian Brook and Laura Briggs, West St. Andrews, Nova Scotia, for giving me the opportunity to collect the erythristic female from West St. Andrews. I thank Kimberly A George, Regional Biologist, Nova Scotia Department of Natural Resources, who first reported to me the female from West St. Andrews. Roger Lloyd, did the professional photography. Katherine Ogden, Assistant Curator/Registrar and Christina McCorry, Acting Assistant Curator/Registrar, Nova Scotia Museum, prepared the map in Figure 3. I am grateful to Mary MacDonald, Acting Assistant Co-ordinator of Interpretation, Museum Naturalist, Nova Scotia Museum of Natural History, for her assistance taking colour notes. At the time of writing both snakes are alive and on display at the Nova Scotia Museum of Natural History, in the dedicated professional care of M. MacDonald.

Literature Cited

Barnes, S. M. 1994. Status and management of Maritime Garter Snakes (*Thamnophis sirtalis pallidula*) on George's Island, Halifax Harbour, Nova Scotia. MSc thesis, Acadia University, Wolfville, Nova Scotia.

Barnes, S. M., C. M. Dubesky, and **T. B. Herman.** 2006. Ecology and Morphology of *Thamnophis sirtalis pallidulus* (Maritime Garter Snake) on Georges Island, Nova Scotia. Northeastern Naturalist 13(1): 73-82.

Bleakney, J. S. 1958. A zoogeographical study of the amphibians and reptiles of eastern Canada. National Museums of Canada Bulletin. 155: 199 pages.

Bleakney, J. S. 1959. *Thamnophis sirtalis sirtalis* (Linnaeus) in eastern Canada, redescription of *T. s. pallidula* Allen. Copeia. 1959(1): 52–56.

Cook, F. R. 1967. An analysis of the Herpetofauna of Prince Edward Island. National Museum of Canada. Bulletin 212. Ottawa. 60 pages.

Cook, F. R. 1984. An introduction to Canadian amphibians and reptiles of Canada. National Museum of Natural Sciences, National Museums of Canada, Ottawa, Ontario.

Cox P. 1903. The snakes of the Maritime Provinces of Canada. Proceedings of the Miramichi Natural History Association 3: 11–20.

Desroches J-F, and **D. Rodrigue.** 2004. Amphibiens et reptiles du Québec et des Maritimes. Waterloo, Editions Michel Quintin Quebec.

Gilhen, J. 1984. Amphibians and reptiles of Nova Scotia. Nova Scotia Museum. Halifax. 162 pages

Gilpin, J. B. 1875. On the serpents of Nova Scotia. Transactions Nova Scotian Institute of Science, IV: 80–88.

Logier, E. B. S. 1939. The reptiles of Ontario. Royal Ontario Museum Handboon (4).

Jones, J. M. 1865. Contributions to the natural history of Nova Scotia: Reptilia. Transactions Nova Scotian Institute Science, I (iii): 114–128.

Merriam, G. and **C.** 1967. Webster's Seventh New Collegiate Dictionary. Thomas Allen & Son Limited, Toronto, Ontario. Page 282 (1221).

Ridgeway, R. 1912. Colour standards and nomenclature. Washington, D. C.

Rossman, D. A, N. B. Ford, and **R. A. Seigel.** 1996. The garter snake: Evolution and ecology. Norman. University of Oklahoma Press.

Smithe, Frank B. 1975. Naturalist's colour guide. Part I, The colour guide. Part II, the colour guide supplement (Color work by Hale Color Consultants, Baltimore). The American Museum of Natural History. New York.

Received 7 November 2009
Accepted 30 June 2010

Effects of Forest Fire on Young-of-the-year Northern Pike, *Esox lucius*, in the Northwest Territories

PETER A. COTT[1], BARRY A. ZAJDLIK[2], KELLY J. BOURASSA[3], MARC LANGE[4], and ANDREW M. GORDON[5]

[1]Department of Fisheries and Oceans, 301, 5204-50th Avenue, Yellowknife, Northwest Territories X1A 1E2 Canada; e-mail: Pete.Cott@dfo-mpo.gc.ca

[2]Zajdlik & Associates Inc., R.R. No. 3, Rockwood, Ontario N0B 2K0 Canada

[3]Golder Associates Limited, No. 9-4905-48th Street, Yellowknife, Northwest Territories X1A 3S3 Canada

[4]Indian and Northern Affairs Canada, Environment & Conservation Box 1500, Yellowknife, Northwest Territories X1A 2R3 Canada

[5]Department of Environmental Biology, University of Guelph, Guelph, Ontario N1G 2W1 Canada

Cott, Peter A., Barry A. Zajdlik, Kelly J. Bourassa, Marc Lange, and Andrew M. Gordon. 2010. Effects of forest fire on young-of-the-year Northern Pike, *Esox lucius* in the Northwest Territories. Canadian Field-Naturalist 124(2): 104–112.

In 1998, a forest fire burned 58% of the forested shoreline surrounding Tibbitt Lake, Northwest Territories, including riparian vegetation used by Northern Pike (*Esox lucius*) as spawning habitat. This presented an opportunity to investigate the effects that habitat disturbance from a natural forest fire had on young-of-the-year (Y-O-Y) Northern Pike. Pike fry were collected from three burned and three unburned sites around Tibbitt Lake in 1999 (the first post-fire spawning season) and again in 2001. Differences in size and relative abundance were evaluated between sites. Y-O-Y Northern Pike were significantly larger at the unburned sites ($P<0.01$) and the relative abundance of Y-O-Y Northern Pike increased significantly at burned sites ($\alpha=0.1$; $P<0.07$) following re-vegetation two years post fire. These differences may be due to fire-induced changes in physical habitat or food availability. Forest fires decrease the density of riparian vegetation, which likely provides better spawning and rearing habitat for Northern Pike in the long-term.

En 1998, un feu de forêt a brûlé 58% de la rive boisée entourant le lac Tibbitt, situé dans les Territoires du Nord-Ouest, y compris la végétation riveraine utilisé par le grand brochet (*Esox lucius*) comme habitat de fraie. Cet événement a présenté une occasion pour étudier les effets causés par un feu de foret sur l'habitat de jeunes de l'année du grand brochet. Les jeunes brochets ont été recueillis sur trois sites brûlées et trois sites non brûlés autour du lac Tibbitt en 1999 (la première année de fraie après le feu de forêt) et à nouveau en 2001. La différence de grandeur et l'abondance relative des poissons ont été analysés entre les différents sites. Les jeunes grands brochets aux sites non-atteints par le feu étaient considérablement plus grands ($P <0,01$) que ceux aux sites brulés. Les sites brulés, subissant une rapide revégétation dans les deux années après le feu, ont augmenté en abondance relative de jeunes grands brochets ($\alpha = 0,1$, $P <0,07$). Ces différences peuvent être dues aux changements induits par le feu sur l'aspect physique de l'habitat ou sur la disponibilité de nourriture. Les incendies de forêt réduisent la densité de la végétation riveraine, qui fournit probablement de meilleure habitat de fraie et d'alevinage pour le grand brochet à long terme.

Key Words: Northern Pike, *Esox lucius*, Northwest Territories, spawning and rearing habitat, prey, forest fire, boreal forest, oligotrophic lake.

During the dry summer of 1998 (Water Survey of Canada 2004), lightning caused a forest fire north of Great Slave Lake, Northwest Territories, which lasted for three months and burned 160 382 hectares of taiga forest (Government of Northwest Territories – Environment and Natural Resources, unpublished data). It reached Tibbitt Lake in early August and burned 58% of the forested shoreline around the lake, comprised of riparian and littoral vegetation (Figure 1). The freshet for the Cameron River, just downstream of Tibbitt Lake, was one month earlier than average, with peak flows barely above the mean flows for the system. This was compounded by unusually low water during the summer months when the fire occurred (Environment Canada 2006). Due to low water at the time of the fire, areas of seasonally flooded riparian and nearshore littoral vegetation (emergent and submergent) were completely burned.

The fire burned large portions of the littoral and riparian vegetation surrounding Tibbitt Lake that would normally be used by Northern Pike (*Esox lucius*) as spawning and rearing habitat. The spring following the forest fire (1999) was the first spawning season where Northern Pike may have been affected by the fire.

The occurrence of the forest fires that reached Tibbitt Lake provided the opportunity to investigate the effects that habitat disturbance from a natural forest fire had on young-of-the-year (Y-O-Y) Northern Pike growth *in situ*. Y-O-Y Northern Pike exhibit very limited dispersal from their natal grounds (Inskip 1982; Cucherousset et al. 2009) and, as such, were potentially affected by habitat alterations caused by the fire. We present a case study investigating the differences in the size and relative abundance of Y-O-Y Northern Pike between burned and unburned habitats found within Tibbitt Lake following a natural forest fire. Unfortu-

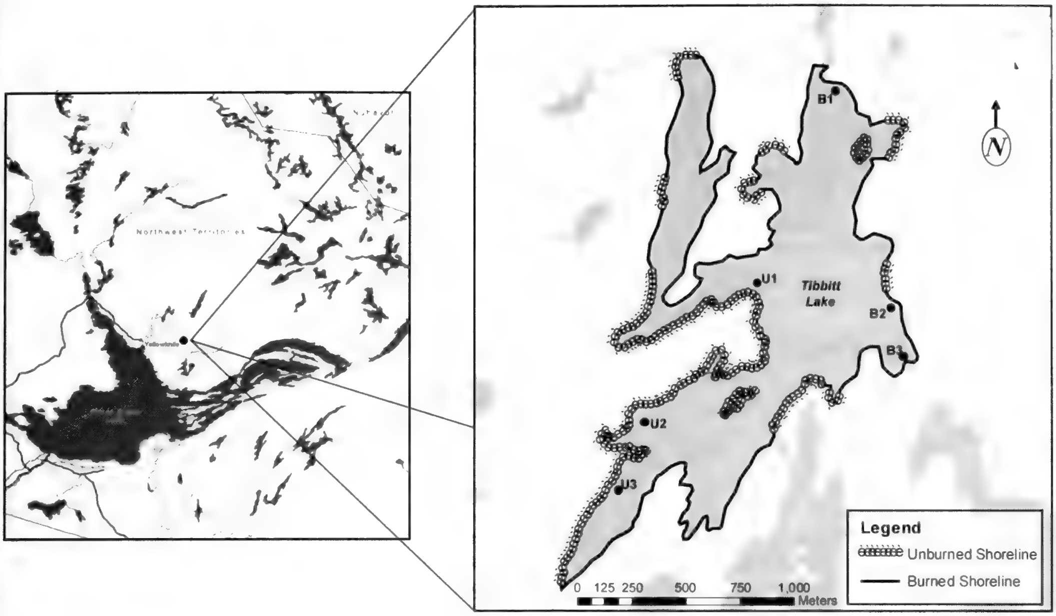


FIGURE 1. Location of Tibbitt Lake, Northwest Territories with the location of burned (B1, B2, B3) and unburned (U1, U2, U3) sampling sites illustrated in the inset.

nately, lakes in the study area are remote and poorly studied, and being a natural event, the fire could not be predicted. Therefore we did not have the virtue of valuable "before" impact data that might be available in more populated areas. As such, this study is opportunistic and observational in nature, using reestablished vegetation in burned sites eight years after the fire as a surrogate of what would be speculated as pre-burned conditions.

Research on the effects of forest fire on aquatic systems has been limited and largely focused on riverine systems (see Rask et al. 1998; Gresswell 1999). Recent literature on the effect of forest fires on lacustrine environments have focused on contaminants transfer (Allen et al. 2005; Garcia and Carignan 2005; Kelly et al. 2006) and fish-community interactions (St-Onge and Magnan 2000; Tonn et al. 2003; 2004). No specific information exists on the effects of forest fire on spawning and rearing Northern Pike, or their habitats in the Northwest Territories (NWT).

In lakes, Northern Pike spawn shortly after the ice has melted in shallow weedy bays and flooded terrestrial vegetation (Scott and Crossman 1973; Casselman and Lewis 1996; Richardson et al. 2001). Adult Northern Pike return to natal grounds in subsequent years to spawn (Frost and Kipling 1967; Raat 1988; Miller et al. 2001). Y-O-Y Northern Pike remain in the vegetative cover and shallow water of these spawning sites (Inskip 1982; Skov et al. 2002; Cucherousset et al. 2009). In a recent study by Cucherousset et al. (2009), it was found that Y-O-Y Northern Pike that had a mean fork length of 51 mm (slightly larger than the mean length collected in this study) moved within an average radial distance of only 14.3 m, and tended to hold in localized habitat patches. As they grow, young Northern Pike gradually move to deeper water and new foraging areas (Franklin and Smith 1963; Inskip 1982; Bry 1996; Cucherousset et al. 2009).

Materials and Methods

Site Description

Located ~70 km east of Yellowknife, NWT, Tibbitt Lake (62°33'N, 113°21'W) is a 143.5 ha oligotrophic lake that connects to the Cameron River system, a 19 267 km^2 watershed that flows into Great Slave Lake (Figure 1). Northern Pike, Lake Whitefish (*Coregonus clupeaformis*), Longnose Sucker (*Catostomus catostomus*), White Sucker (*C. commersoni*) and Spottail Shiner (*Notropis hudsonius*) have been documented in Tibbitt Lake (Falk 1979). Sampling by the authors also revealed the presence of Burbot (*Lota lota*) and Lake Chub (*Couesius plumbeus*).

The forest surrounding Tibbitt Lake is boreal. It is composed mainly of Black Spruce (*Picea mariana*), Jack Pine (*Pinus banksiana*), and White Birch (*Betula papyrifera*), with River Alder (*Alnus rugosa*) and willow (*Salix* spp.) dominating the 15.2 km shoreline. The landscape is undulating Precambrian bedrock, with a 4-9% slope, and well-drained mineral soils in the area have a 20-75 cm rooting depth.

Flooded riparian vegetation in unburned sites included willow, Bearberry (*Arctostaphylos uva-ursi*),

TABLE 1. Habitat characteristics at unburned and burned sites, Tibbitt Lake, Northwest Territories. Each site is bound by a transition to deeper water ('trans. deep'), from the wetted shoreline. The water depth at riparian/aquatic vegetation interface is 'trans. shallow'. Data represent re-vegetated condition (2006: 8 years after the fire), as a surrogate to the % cover of vegetation that existed prior to the fire.

	Site characteristics				Vegetation		Substrate							
Site	Area (m^2)	Slope	Depth deep (m)	Depth shallow (m)	% Cover deep	% Cover shallow	bedrock %	boulder %	rubble %	cobble %	gravel %	sand %	silt/clay %	detritus %
U1	1656	0.07	1.2	0.2	15	70	0	10	0	20	0	5	40	25
U2	2520	0.04	1.3	0.3	25	80	20	10	0	0	0	0	30	30
U3	1880	0.06	1.1	0.2	25	60	20	10	0	10	0	0	30	30
B1	3458	0.03	1.2	0.25	15	90	0	2.5	0	2.5	0	30	25	40
B2	1066	0.07	0.9	0.2	5	90	0	5	0	15	0	5	50	20
B3	1539	0.05	1.4	0.2	10	90	0	5	0	5	0	0	55	20

Dwarf Bilberry (*Vaccinium caespitosum*), Labrador Tea (*Ledum groenlandicum*), Water Birch (*Betula occidentalis*), Green Tongue Liverwort (*Marchantia polymorpha*), Wild Mint (*Mentha arvensis*), Bicknell's Geranium (*Geranium bicknellii*), Pink Corydalis (*Corydalis sempervirens*), Submerged Common Scouring-rush (*Equisetum hyemale*), Common Horsetail (*Equisetum arvense*), and sedges (*Carex* spp).

In lakes with unburned catchments, Northern Pike select spawning and rearing sites that are shallow, with soft bottom. The areas they select also have connectivity to deeper water, lack considerable water current and protection from prevailing winds, and possess a mix of seasonally flooded riparian and littoral vegetation (Bry 1996; Casselman and Lewis 1996; Richardson et al. 2001).

Field Sampling

We selected our sampling sites in both burned and unburned areas of the lake (Table 1). Burned sites were selected using the same criteria as unburned sites; however, burned sites were completely devoid of all riparian and littoral vegetation (Table 1). As a surrogate representation of the amount of vegetation cover that existed prior to the fire, a vegetation survey was conducted in mid-August 2006 at the sample sites once littoral and riparian vegetation had re-established in the burned shoreline areas (Table 1). This confirmed predictions that the burned sites selected likely represented good spawning and nursery habitat preceding the fire. Sites were located >200 m apart, separated by unsuitable habitat of exposed bedrock shoreline, which would make mixing of Y-O-Y Northern Pike between sites at time of sampling unlikely (Figure 1). A summary of habitat characteristics at the sample sites is given in Table 1. For a summary of the known habitat requirements for Northern Pike spawning and Y-O-Y rearing in the NWT see Richardson et al. (2001).

Sampling for Y-O-Y Northern Pike was conducted at the six sites in the last week of June 1999 and again the first week of July 2001, using kick nets at three sites in each of the burned and unburned areas. The nets were 650 mm by 1400 mm (64 μm mesh), with two pole handles, a floating top line, and a weighted ballast line. Sampling was conducted by drawing an open net through the water with the ballast line at the substrate surface for 1 or 2 m and then drawing the net to the surface while folding, trapping the contents inside. Each net could sample a swath of habitat 1 m wide. Each site was sampled continuously for 50 minutes, with an average efficiency (including sorting) of 6.25 $m^2 \cdot min^{-1}$. The contents of the net were sorted and all Y-O-Y Northern Pike collected. Northern Pike < 85 mm in total length were considered Y-O-Y (Scott and Crossman 1973). Y-O-Y Northern Pike were counted, weighed (to the nearest 0.001 g wet weight) and total length measured to the nearest 0.5 mm.

In 1999, water quality data were collected at each site using a Hydrolab Surveyor 3® multi-parameter meter. Measured parameters included dissolved oxygen, pH, conductivity, turbidity, alkalinity and total dissolved solids, suspended solids and water temperatures. Water samples were also collected from the littoral zone of each site and analyzed for selected trace elements and nutrients (Taiga Laboratory, Yellowknife, NWT). A one-way ANOVA (α=0.1) was used to determine if selected chemical parameters were significantly different between burned and unburned sites and compared to the Canadian Environmental Quality Guidelines (commonly referred to as CCME Guidelines) for the protection of freshwater or aquatic life (Canadian Council of Ministers of the Environment 1999).

Statistical Analysis

Fish wet weights, lengths, and catch per unit effort (CPUE) were modelled as potential functions of two factors burn status and year, and a year/burn status interaction. Since the effect of burn is nested within site, a random effect was used to describe the among-site variability, and burn and year were treated as fixed effects. Since CPUE was measured on a site basis, the CPUE and site effects are completely confounded which could confuse interpretation. However, this problem was ultimately resolved since the random effect term proved unnecessary.

Mixed effects models were built following the principle of parsimony, with significance levels for term

TABLE 2. Summary of fixed effects for assessment of burn status on Y-O-Y Northern Pike weight and length.

	Source	Numerator df	Denominator df	F-Statistic	P-value
weight	intercept	1	196	30.25820	<.0001
	burn status	1	4	5.96309	0.0711
	year	1	196	61.86041	<.0001
length	intercept	1	196	549.1257	<.0001
	burn status	1	4	4.3525	0.1053
	year	1	196	30.0064	<.0001

deletion ≈ 0.05. Likelihood ratio tests were used for random effects and marginal F-tests for fixed effects. Akaike's Information Criterion (AIC) adjusts the likelihood by penalizing the inclusion of parameters, because the addition of even non-informative parameters will improve model fit, as measured by the likelihood. Therefore the AIC was chosen between closely contending models.

Residual diagnostics included within-term residual plots to assess homogeneity, observed versus predicted plots to assess adequacy of fit and absence of residual structure, and Shapiro-Wilk tests to assess the normality assumptions of all models. Mixed effects model parameters were estimated using restricted maximum likelihood and parameters of general linear models were estimated using maximum likelihood.

The final mixed-effects models described fish wet weights or total lengths include terms for burn status, year and a random effect for site. The year/burn interaction term did not describe a significant proportion of variability in fish weight or total length and therefore was not retained in either model. The total length model uses a square root transformation on length to reduce kurtosis. The CPUE model is a simple general linear model rather than a mixed effects model.

This study was conducted as per the Freshwater Institute Animal Care Committee Protocol and scientific collection licenses (S. 52 of the Fisheries Act) SLE-99/00-215, SLE-00/01-229, and SLE-03/04-277 that were obtained for this project.

Results

Fixed effects model results for weight are presented in Table 2. The model shows that the wet weight of fish collected from unburned areas significantly increased at the 10% level of significance relative to fish collected from burned areas. The fish lengths were modeled as a function of burn status and year and a year/burn status interaction as described above. Fixed effects results for length are presented in Table 2.

The length of fish collected from burned areas significantly decreased in both years at roughly the 10% level of significance relative to fish collected from unburned areas. Both models also showed that there was a significant general increase in Y-O-Y Northern Pike size (weight and length) from 1999 to 2001. The mean total length of Y-O-Y Northern Pike captured in 1999 at the unburned sites was 35.2 mm (21.5-60.0 mm, ±1.2 [SE], n=69) and at the burned sites was 22.4 mm (9.5-37.0 mm, ±1.5 [SE], n=22) (Figure 2a). In 2001, the mean total length of Y-O-Y Northern Pike captured at the unburned sites was greater than those caught in the burned sites, at 43.4 mm (22.0-73.0 mm, ±1.8 [SE], n=49) and 30.6 mm (14.0-47.0 mm, ±1.8 [SE], n=63), respectively (Figure 2a). In both years, the mean wet weights of Y-O-Y Northern Pike captured at the unburned sites were heavier than those captured at burned sites, with 0.40 g (0.07-1.68 g, ±0.04 [SE], n=69) and 0.11 g (0.07-0.43 g, ±0.03 [SE], n=22) at the unburned and burned sites in 1999, and 0.92 g (0.10-3.19 g, ±0.10 [SE], n=49) and 0.28 g (0.02-0.88 g, ±0.02 [SE], n=63) at the burned sites and unburned sites in 2001 (Figure 2b). Regardless of site, all Y-O-Y Northern Pike sampled in 2001 were proportionately larger (approximately 30%) than those sampled in 1999; likely because sampling was conducted later in the 2001 growing season (Figure 2a, 2b).

TABLE 3. ANOVA table for Y-O-Y Northern Pike catch-per-unit-effort model.

Term	df	Mean Square	F-Statistic	P-Value
Year	1	274.62	4.2303	0.06675
Residuals	10	64.92		

CPUE is significantly affected by year (P-value = 0.0668; Table 3). The mean CPUE of Y-O-Y Northern Pike caught in 1999 at the unburned sites was greater, at 13.8 fish×h-1 (±7.3) than the CPUE of pike caught at the burned sites at 4.4 fish×h-1 (±2.9) for Y-O-Y Northern. This was not the case in 2001, with 16.3 fish× h-1 (±3.2) collected in the unburned sites and 21.0 fish×h-1 (±3.1) in the burned sites (Figure 2c).

Most parameters of water chemistry vary between burned and unburned lakes, (Carignan et al. 2000). None of the water quality parameters sampled in 1999 were found to be significantly different between unburned and burned areas, and therefore, these parameters were not sampled in 2001. However, the similarities in water quality parameters measured would not be unexpected in a lake the size of Tibbitt Lake, and was likely due to effective mixing by lake circulation driven by wind mixing (Fee et al., 1996; Wetzel, 2001) and river flow through the lake (Wetzel 2001). No water chemistry parameters sampled in 1999 exceed-

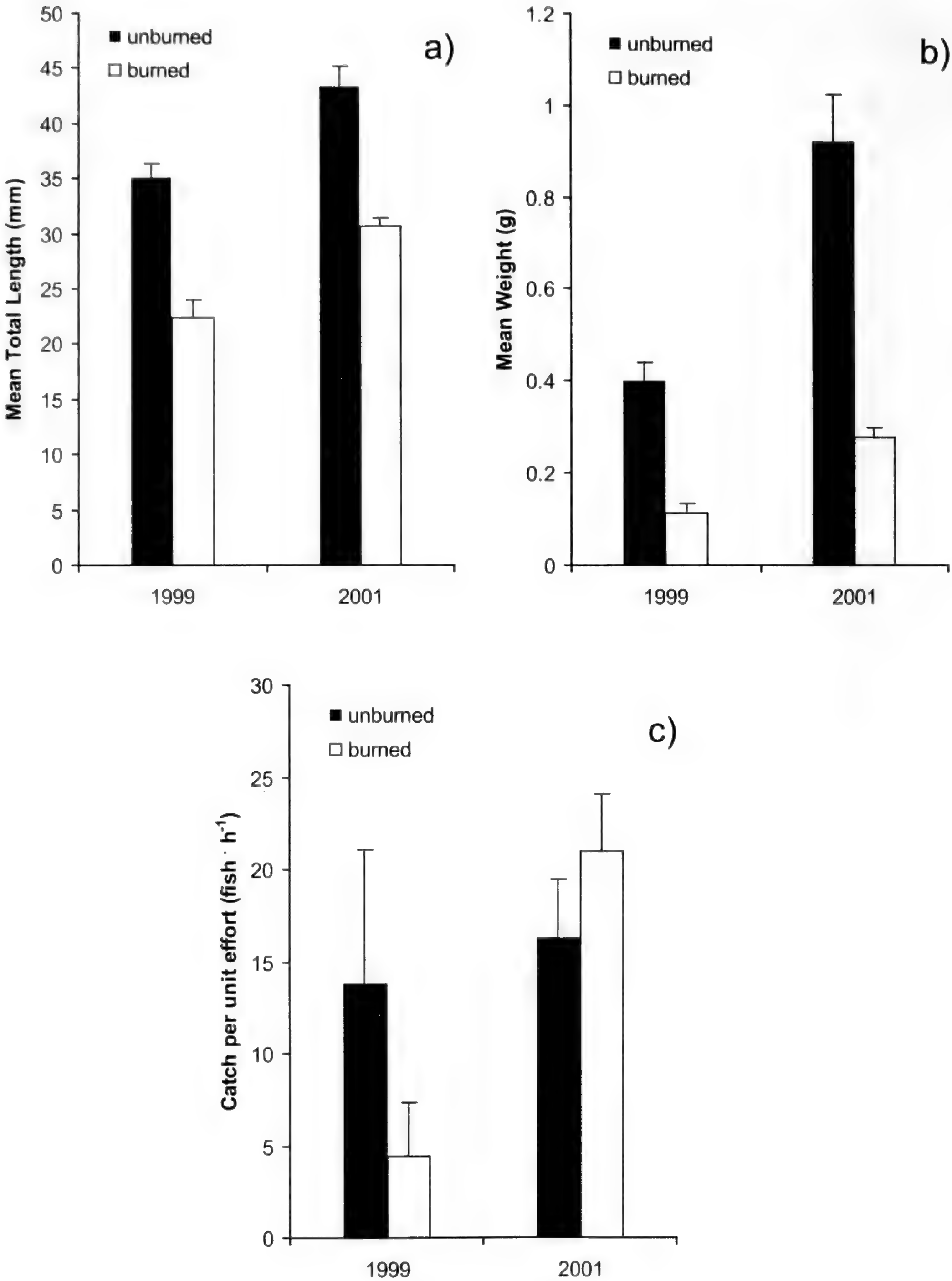


FIGURE 2. A comparison of a) mean total length (mm) ±[SE]; b) mean weight (g) ±[SE]; and c) abundance (catch per unit effort) ±[SE], for young-of-the-year Northern Pike sampled at burned and unburned sites in 1999 and 2001, Tibbitt Lake, Northwest Territories.

ed the CCME Guidelines for the protection of freshwater or aquatic life, and are not presented herein.

Unburned habitat remained similar between the years 1999, 2001 and 2006 as would be expected. Burned sites were void of riparian and emergent vegetation in 1999. Some macrophytes were present, but sparse and in deeper water. In 2001, the burned sites were between 40–60% re-vegetated. By 2006, unburned and burned sites were similar in terms of vegetation type and coverage (Table 1).

Discussion

Both of the variables considered (i.e., year and burn status) were associated with changes in Y-O-Y Northern Pike growth. After accounting for year effects, burn status caused reductions in growth through changes to spawning and rearing habitat. This was influenced by the complete removal of seasonally flooded riparian and littoral vegetation due to the fire. Growth increased with the variable year, possibly owing to the slightly later sampling period in 2001 compared to 1999.

Northern Pike growth can be influenced by food quantity and quality, temperature, length of growing season or a combination thereof (Franklin and Smith 1963; Frost and Kipling 1967; Scott and Crossman 1973; Craig and Babaluk 1989; Casselman 1996; Venturelli and Tonn 2006). It is plausible that the consistently smaller size of pike fry in burned areas compared to unburned areas in the years studied may be associated with changes in physical habitat and poorer food resources. Growth rates of Y-O-Y pike can be highly variable and dependent on habitat (Casselman 1996; Skov and Koed 2004), and can be rapid, with lengths of up to 43 mm possible in their first month (Scott and Crossman 1973).

Northern Pike fry eat invertebrates such as insect larvae and large zooplankton that is primarily found in shallow vegetated areas (Scott and Crossman 1973; Bry 1996; Beaudoin et al. 1999). These same types of vegetated areas existed where fire affected Tibbitt Lake. Where invertebrates are limited in terms of abundance or due to interspecific competition, cannibalism may increase (Beaudoin et al. 1999). It is possible that the quality and quantity of invertebrates were greater in undisturbed habitat at the unburned sites, and offered better feeding opportunities to Y-O-Y Northern Pike compared to those from the burned sites. Minshall (2003) suggests that changes to macro-invertebrates in streams following a burn are generally minor and difficult to discern. However, a reduction in macro-invertebrate density and diversity in association with forest disturbances was noted by Rinne (1996). In lakes, burns have been shown to increase productivity due to nutrient enrichment (Garcia and Carignan 2005). Increases in productivity have led to changes in growth rates of macro-invertebrates, and in turn shifted diet preferences of fishes (Kelly et al. 2006; Allen et al. 2005). Dietary alterations can lead to enhanced growth of Northern Pike and other fishes, and longer food chains can occur in post-fire lakes as a result of increased productivity restructuring food webs and enhancing the trophic position of piscivores (Kelly et al. 2006). If productivity increased, poor spawning and rearing success at the burned sites may have been compensated for by increased success at the unburned sites. Alternatively, stunting of Northern Pike growth rates can occur if diet is poor (Venturelli and Tonn 2006). If the fire negatively impacted the quality and quantity of food sources in the burned sites, this could account for the proportionately smaller pike fry at these sites compared to the unburned sites. Growth rates can be compromised in one year or less following environmental disturbances where prey quality and quantity are affected (Venturelli and Tonn 2006). We do not have general pre-fire data or data specific to invertebrate populations. Whether the fire altered prey items in Tibbitt Lake, and subsequently affected pike fry, is speculation.

All of the components of suitable Northern Pike spawning habitat (Bry 1996; Casselman and Lewis 1996; Richardson et al. 2001) were found at the sample sites (Table 1). However, one notable exception of the burned sites is that seasonally flooded riparian vegetation and littoral vegetation was absent the year following the fire. Northern Pike spawn after ice out, which, in a lake the size of Tibbitt Lake (143.5 ha) would have occurred at the same time for all six sites sampled. However, it is possible that Northern Pike preferentially selected the undisturbed habitat of the unburned areas as spawning sites. The lack of cover, and possibly prey, would amount to more energy expenditure and less energy uptake in the burned sites compared to the unburned sites, and could influence growth of Y-O-Y Northern Pike. Skov and Koed (2004) found that pike fry within more complex habitats (as apposed to open water) were faster growing.

No difference in CPUE of Y-O-Y Northern Pike was found at unburned sites between years. This was expected since the unburned habitat was not altered during that time. However, there were more Y-O-Y Northern Pike sampled at the burned sites during 2001 than in 1999. It is possible that Northern Pike fry experienced greater survival during 2001 in the burned areas because vegetation grew back. Skov and Berg (1999) attributed the preference of Y-O-Y Northern Pike for complex habitats to a decrease in predation. The vegetation re-growth would have improved physical habitat quality, increased cover thereby reducing predation, and presumably increased the quality and quantity of prey items. As with average weight, any increase in the relative abundance of fish is indicative of a response to reduced stress or a positive change in living conditions (Regier and Loftus 1972).

Mortality of Northern Pike eggs and young can be as high as 99% in stressed environments (Scott and Crossman 1973). In Tibbitt Lake, an increase in egg

and fry mortality may have contributed to low catches associated with burned sites during 1999 relative to 2001. Lower pike fry abundance is likely a result of a lack of flooded riparian and littoral vegetation (as a result of the fire) used for spawning substrate and cover, and possibly due to a combination of increased cannibalism, reduced quality and quantity of food supply (Figure 2c). Research conducted in the upper Mississippi River, USA, found that catches of Y-O-Y Northern Pike were 10 times greater in vegetated areas compared to non-vegetated areas (Holland and Huston 1984). Dense flooded terrestrial vegetation provides cover and ambush opportunities for Northern Pike fry and keeps them spatially separated from each other, while preventing access by larger Northern Pike that may feed on them (Inskip 1982; Raat 1988). In the absence of suitable cover, young Northern Pike are known to exhibit increased cannibalism (Bryan 1967; Inskip 1982; Raat 1988). Cannibalism also may increase as a result of reduced invertebrate abundance associated with less vegetated habitats (Franklin and Smith 1963). St-Onge and Magnan (2000) reported reduced catches of young Yellow Perch (*Perca flavenscens*) and White Sucker in Shield lakes affected by logging and fire, and suspected that the resultant lower food quality had a negative effect on the survival of young fish. Kelly et al. (2006) reported that fishes that were previously benthivores became piscivores when availability of fish-based food sources improved, increasing their trophic position.

Northern Pike in Tibbitt Lake selected both unburned and burned sites to spawn (as evident by pike fry captured at all six sites), despite the latter being very poor quality habitat the year following the fire. Frost and Bryan (1967); Kipling (1967); and Cott (2004) reported that Northern Pike spawn over a variety of habitat types if ideal spawning habitat is not available. Also, Frost and Kipling (1967); Raat (1988); and Miller et al. (2001) reported spawning and natal site fidelity by Northern Pike. The occurrence of Northern Pike fry in the vegetation-deficient burned areas supported these findings. With the ability of a single Northern Pike able to produce >500 000 eggs (Scott and Crossman 1973), it is reasonable to assume that some eggs released at the burned sites would have hatched despite the habitat limitations.

Tonn et al. (2004) found fewer small Northern Pike in lakes subjected to forest fire in Northern Alberta compared to those that were not, suggesting possible population level impacts. If fire results in the loss of habitat, and in turn, reduced spawning success and the potential for increased cannibalism, this could reduce the abundance of the cohort spawned in years immediately following a forest fire. This impact would be exacerbated if the fire follows a low water period, as in the case of the Tibbitt Lake fire. Low water levels result in less flooding of riparian vegetation and therefore less spawning habitat. Also, lower water levels increase the susceptibility of that habitat to being burned in the event of a forest fire, as was clearly the case at Tibbitt Lake. Reduction in suitable habitat has been demonstrated to increase aggression and competition among Y-O-Y Northern Pike in the nursery areas (Frost and Kipling 1967), factors that may lead to higher mortality and a weak year class (Scott and Crossman 1973).

New vegetation had begun to establish by the end of the summer in the year following the fire. Although it is well recognized that vegetation is an essential component of Northern Pike habitat that provides spawning, feeding, rearing and cover opportunities (Witcomb 1965; Scott and Crossman 1973; Benson 1980; Bry 1996; Casselman 1996; Grimm and Klinge 1996; Skov and Berg 1999; Skov et al. 2002; Skov and Koed 2004), vegetation that is extremely dense can be undesirable and can hinder the Northern Pikes' visual-based hunting tactics (Headrick and Carline 1993; Casselman and Lewis 1996). Further, Eklov (1997) found the size of Northern Pike is inversely related to vegetation density in oligotrophic lakes (i.e., pike fry occupy more densely vegetated areas than do adults). Northern Pike fry also require intermediate densities of vegetation for rearing habitat (Anderson 1993; Casselman and Lewis 1996). The fire may have had a positive effect for Northern Pike by burning dense vegetation, coarse woody debris and other detritus, allowing these sites to reestablish with new vegetation that is more accessible for spawning and provides better nursery habitat, relative to unburned areas.

Despite the opportunistic nature of this study, the results of this study, augmented by consideration of un-measurable confounding factors, suggest that forest fires which burn riparian and littoral vegetation can affect the size and abundance of Y-O-Y Northern Pike. The results show that Northern Pike fry at the unburned sites were significantly larger than those sampled at burned sites, both in the year following the fire and three years after the fire. As there were no differences in water chemistry between burned and unburned sites, the differences in Northern Pike growth between sites is likely due to changes in physical habitat. There was no significant difference in relative abundance (as measured by CPUE) of Y-O-Y Northern Pike between unburned and burned sites in a given year, but relative abundance increased in the burned sites as vegetation reestablished. In low water years, reduced flooding of back bays and other low-lying shorelines can make these habitats more susceptible to the effects of fire. Periodic burning of shoreline vegetation may be a beneficial effect of forest fires, by thinning out vegetation that is too dense to be useful for pike spawning. Fire suppression around shorelines may therefore have more detrimental effects on the long-term success of Northern Pike populations than if shorelines were left to burn naturally. This is consistent with the current NWT forest fire management practices where fire retardants are not applied on riparian areas (Lance

Schmidt – Environment and Natural Resources, Government of Northwest Territories, Yellowknife, NWT, personal communication 2004).

The boreal forests of the NWT have had a fire cycle of approximately 80 – 110 years. Such disturbances are integral in the functioning and ecology of boreal ecosystems (Kimmins 2004). Northern Pike have also been a part of this ecosystem since the departure of the last continental glaciers and have successfully survived in this fire disturbance regime. Forest fires that burn seasonally inundated riparian vegetation and littoral vegetation may have negative short-term effects on Northern Pike populations through disturbing spawning habitat. However, this type of burning may provide long-term benefits by allowing new vegetation to reestablish, providing better spawning and rearing habitat for Northern Pike.

This study provides insight into the effect forest fire has on Northern Pike, possibly through changes in their spawning and rearing habitat. The study would be strengthened if data on diet and invertebrate populations were collected, yet a similar opportunity would need to be presented in the future. These data, or if pre-fire data available, would greatly assist in determining the causality of changes in the size and relative abundance of pike fry by enabling an assessment of the quality and quantity of prey available (including rates of cannibalism) between burned and unburned areas.

Acknowledgments

The authors thank Suzanne Carrière with the Government of the Northwest Territories – Environment and Natural Resources, for the invitation to participate in the Tibbitt Lake fire study, as well as those who provided assistance various aspects of this project; Ron Allen, James Auld, John Babaluk, Marcy Bast, Pete Brunette, Julie Dahl, Corrie Gibson, Alex Hood, Lyndon Kivi, Colin Lake, Andy Majewski, Josef McLeod, Serge Metikosh, Caroline Morissette, Sarah Olivier, Lorraine Sawdon, Elva Simundsson, Daria Smeh, Murray Somers, Sam Stephenson, Bud Timmins, Dave Tyson, Anne Wilson and Kelly Withers. The valuable comments of four anonymous reviewers improved this manuscript.

Documents Cited (marked * in text)

Anderson, P. G. 1993. Adaptation of a habitat suitability model for prioritizing habitat rehabilitation needs of northern pike (*Esox lucius*). M.Sc thesis, Trent University Peterborough, Ontario.

Environment Canada. 2006. Archived Hydrometric Data. <http://www.wsc.ec.gc.ca/hydat/H2O/index_e.cfm?cnme=mainStation_e.cfm> Last accessed 17 August 2009.

Water Survey of Canada. 2004. Archived Hydrometric Data. <http://www.wsc.ec.gc.ca/hydat/H2O/> Last accessed 26 January 2006.

Literature Cited

Allen, E. W., E. E. Prepas, S. Gabos, W. M. J. Strachan, and **W. Zhang.** 2005. Methyl mercury concentrations in macroinvertebrates and fish from burned and undisturbed lakes on the Boreal Plain. Canadian Journal of Fisheries and Aquatic Sciences 62: 1963-1977.

Beaudoin, C. P., W. M. Tonn, E. E. Prepas, and **L. I. Wassenaar.** 1999. Individual specialization and trophic adaptability of northern pike (*Esox lucius*): an isotope and dietary analysis. Oecologia 120: 386-396.

Benson, N. G. 1980. Effects of post-impoundment shore modifications on fish populations in the Missouri River reservoir. U.S. Fish and Wildlife Service Research Report 80. 32 pages.

Bry, C. 1996. Role of vegetation in the life cycle of pike. Pages 45-67 *in* Pike: biology and exploitation. *Edited by* J. F. Craig. Chapman and Hall, London. 298 pages

Bryan, J. E. 1967. Northern pike production in Phalen Pond, Minnesota. Journal of the Minnesota Academy of Science 34: 101-109.

Canadian Council of Ministers of the Environment. 1999. Canadian environmental quality guidelines. Canadian Council of Ministers of the Environment, Winnipeg, Manitoba.

Carignan, R., P. D'Arcy, and **S. Lamontagne.** 2000. Comparative impacts of fire and forest harvesting on water quality in Boreal Shield Lakes. Canadian Journal of Fisheries and Aquatic Sciences 57: 105-117.

Casselman, J. M. 1996. Age, growth and environmental requirements of pike. Pages 69-101 *in* Pike: biology and exploitation. *Edited by* J. F. Craig. Chapman and Hall, London. 298 pages.

Casselman, J. M., and **C. A. Lewis.** 1996. Habitat requirements of northern pike (*Esox lucius*). Canadian Journal of Fisheries and Aquatic Sciences 53: 161-174.

Cott, P. A. 2004. Northern pike (*Esox lucius*) habitat enhancement in the Northwest Territories. Canadian Technical Report of Fisheries and Aquatic Sciences 2528: vii + 32 pages.

Craig, J. F., and **J. A. Babaluk.** 1989. Relationship of condition of walleye (Stizostedion vitreum) and northern pike (*Esox lucius*) to water clarity, with special reference to Dauphin Lake, Manitoba. Canadian Journal of Fisheries and Aquatic Sciences 46: 1581-1586.

Cucherousset, J., J. -M. Paillisson, A. Cuzol, and **J.-M. Roussel.** 2009. Spatial Distribution of young of the year northern pike (*Esox lucius* L.) in a temporarily flooded nursery area. Ecology of Freshwater Fish 18: 314-322.

Eklov, P. 1997. Effects of habitat complexity and prey abundance on the spatial and temporal distributions of perch (*Perca fluviatilis*) and pike (*Esox lucius*). Canadian Journal of Fisheries and Aquatic Sciences 54: 1520-1531.

Falk, M. R. 1979. Biological and limnological data on lakes along the Ingraham Trail, Northwest Territories, 1973-74. Canadian Fisheries and Marine Services Data Report 125. iv-36 pages.

Fee, E. J., R. E. Hecky, S. E. M. Kasian, and **D. R. Cruikshank.** 1996. Effects of lake size, water clarity, and climatic variability on mixing depths in Canadian Shield lakes. Limnology and Oceanography 41: 912-920.

Franklin, D. R., and **L. L. Smith Jr.** 1963. Early life history of the northern pike, Esox lucius L., with special reference

to the factors influencing the numerical strength of year classes. Transactions of the American Fisheries Society 92: 91-110.

Frost, W. E., and **C. Kipling.** 1967. A study of reproduction, early life, weight-length relationship and growth of pike, *Esox lucius* L., in Windermere. Journal of Animal Ecology 36: 651-693.

Garcia, E., and **R. Carignan.** 2005. Mercury concentrations in fish from forest harvesting and fire-impacted Canadian boreal lakes compared using stable isotopes of nitrogen. Environmental Toxicology and Chemistry 24: 685-693.

Gresswell, R. E. 1999. Fire and aquatic ecosystems in forested biomes of North America. Transactions of the American Fisheries Society 128: 193-221.

Grimm, M. P., and **M. Klinge.** 1996. Pike and some aspects of its dependence on vegetation. Pages 125-156 *in* Pike: biology and exploitation. *Edited by* J. F. Craig. Chapman and Hall, London. 298 pages.

Headrick, M. R., and **R. F. Carline.** 1993. Restricted summer habitat and growth of northern pike in two southern Ohio impoundments. Transactions of the American Fisheries Society 122: 228-236.

Holland, L. E., and **M. L. Huston.** 1984. Relationship of young-of-the-year northern pike to aquatic vegetation types in backwaters of the upper Mississippi River. North American Journal of Fisheries Management 4: 514-522.

Inskip, P. D. 1982. Habitat suitability index models: Northern Pike. U.S. Department of the Interior, Fish and Wildlife Service. FWS/OBS-82/10.17. 40 pages.

Kelly, E. N., D. W. Schindler, V. L. St. Louis, D. B. Donald, and **K. E. Vladicka.** 2006. Forest fire increases mercury accumulation by fishes via food web restructuring and increased mercury inputs. Proceedings of the National Academy of Sciences 103: 19380-19385.

Kimmins, J. P. 2004. Forest ecology: a foundation for sustainable management and environmental ethics in forestry (3rd edition). Prentice Hall, New Jersey. 611 pages.

Miller, L. M., L. Kallemeyn, and **W. Senanan.** 2001. Spawning-site and natal-site fidelity by northern pike in a large lake: mark-recapture and genetic evidence. Transactions of the American Fisheries Society 130: 307-316.

Minshall, G. W. 2003. Responses of stream benthic macroinvertebrates to fire. Forest Ecology and Management 178: 155-161.

Raat, A. J. 1988. Synopsis of biological data on the northern pike, *Esox lucius* Linnaeus, 1758. FAO Fisheries Synopsis Review 2: 178

Rask, M. R., K. Nyberg, S. L. Markkanen, and **A. Ojala.** 1998. Forestry in catchments: effects on water quality, plankton, zoobenthos and fish in small lakes. Boreal Environment Research 3: 75-86.

Regier H. A., and **K. H. Loftus.** 1972. Effects of fisheries exploitation on salmonid communities in oligotrophic lakes. Journal of the Fisheries Research Board of Canada 29: 959-968.

Richardson, E. S., J. D. Reist, and **C. K. Minns.** 2001. Life history characteristics of freshwater fish occurring in the Northwest Territories and Nunavut, with major emphasis on lake habitat requirements. Canadian Manuscript Reptort of Fisheries and Aquatic Sciences 2569: vii+149 pages.

Rinne, J. N. 1996. Short-term effects of wildfire on fishes and aquatic macroinvertebrates in the southwestern United States. North American Journal of Fisheries Management 16: 653-658.

Scott, W. B., and **E. J. Crossman.** 1973. Freshwater fishes of Canada. Fisheries Research Board of Canada Bulletin 184. 966 pages.

Skov, C., and **S. Berg.** 1999. Utilization of natural and artificial habitats by YOY pike in a biomanipulated lake. Hydrobiologica 48/49: 115-122.

Skov, C., S. Berg, L. Jacobson, and **N. Jepsen.** 2002. Habitat Use and foraging success of 0+ pike (Esox lucius L.) in experimental ponds related to prey fish, water transparency and light intensity. Ecology of Freshwater Fish 11: 65-73.

Skov, C., and **A. Koed.** 2004. Habitat Use of 0+ year pike in experimental ponds in relation to cannibalism, zooplankton, water transparency and habitat complexity. Journal of Fish Biology 64: 448-459.

St-Onge, I., and **P. Magnan.** 2000. Impacts of logging and natural fires on fish communities of Laurentian Shield lakes. Canadian Journal of Fisheries and Aquatic Sciences 57: 165-174.

Tonn, W. M., S. M. Boss, P. K. M. Aku, G. J. Scrimgeour, and **C. A. Paszkowski.** 2004. Fish assemblages in subarctic lakes: does fire affect fish-environment relationships in northern Alberta? Transactions of the American Fisheries Society 133: 132-143.

Tonn, W. M., C. A. Paszkowski, G. J. Scrimgeour, P. K. M. Aku, M. Lange, E. E. Prepas, and **K. Westcott.** 2003. Effects of forest harvesting and fire on fish assemblages in boreal plains lakes: a reference condition approach. Transactions of the American Fisheries Society 132: 514-523.

Venturelli, P. A., and **W. M. Tonn.** 2006. Diet and Growth of Northern Pike in the Absence of Prey Fishes: Initial Consequences for Persisting in Disturbance-Prone Lakes. Transactions of the American Fisheries Society 135: 1512-1522.

Wetzel, R. G. 2001. Limnology: Lake and River Ecosystems, (3rd edition). Academic Press, San Diego. [page 1006].

Witcomb, D. 1965. The importance of aquatic weeds in the general economy of freshwater fish habitats. Pages 49-56 *in* Proceedings of the Second British Coarse Fish Conference. *Edited by* J. W. Jones and P. H. Tombleson. Liverpool, United Kingdom.

Received 26 November 2009
Accepted 14 May 2010

Occurrence of Lake Chub, *Couesius plumbeus*, in Northern Labrador

Wendy K. Michaud[1, 4], Robert C. Perry[2], J. Brian Dempson[3], Milton Shears[3], and Michael Powers[1]

[1]Department of Biology, University of Waterloo, Waterloo, Ontario N2L 3G1 Canada
[2]Wildlife Division, Department of Environment and Conservation, Corner Brook, Newfoundland and Labrador, Canada
[3]Fisheries and Oceans Canada, St. John's, Newfoundland and Labrador, Canada
[4]Corresponding author: Wendy Michaud; e-mail: wmichaud@sciborg.uwaterloo.ca

Michaud, Wendy K., Robert C. Perry, J. Brian Dempson, Milton Shears, and Michael Powers. 2010. Occurrence of Lake Chub, *Couesius plumbeus*, in northern Labrador. Canadian Field-Naturalist 124(2): 113–117.

Lake Chub (*Couesius plumbeus*) were recently found in seven previously undocumented locations in northern Labrador. These populations represent the first recorded accounts of this species in the Labrador region north of the Churchill River drainage and east of the George River. Lake Chub likely invaded this region via dispersal routes provided by eastern spillways of glacial Lake Naskaupi.

Key Words: Lake Chub, *Couesius plumbeus*, species distribution, post-glacial dispersal, Labrador.

The distribution of freshwater species in the Labrador region of the province of Newfoundland and Labrador, like many other areas in northern Canada, remains poorly documented (Black et al. 1986). This is perhaps due to the lack of human intrusion into the region, which is largely unpopulated and undeveloped. The distribution of many species in the Labrador region has been compiled from surveys conducted in coastal areas or in the Churchill River basin (e.g., Backus 1957; Ryan 1980), with lakes and rivers in other inland areas remaining largely unexplored.

Lake Chub, *Couesius plumbeus* (Agassiz), has the most widespread northern distribution of any cyprinid species in North America, where it is found in lakes and rivers throughout continental Canada and the northern United States (Scott and Crossman 1973). However, there are relatively few documented occurrences of the species from the Labrador region. As part of an early ichthyofaunal survey, Backus (1951, 1957) reported finding Lake Chub in Lake Melville and what was then called the Hamilton River basin (now the Churchill River). Black et al. (1986) published the most recent compilation of distributional records for Lake Chub in Labrador, with observations reported primarily from the Churchill River basin (Figure 1). Several reports do note the presence of Lake Chub in major drainages of eastern Ungava Bay, including the George River, Koksoak River, and Whale River (e.g., McAllister and Bleakney 1960; Power and Oliver 1961; Harper 1961; Power et al. 2009), as well as some of the minor drainages (e.g., the Nepihgee River: Power et al. 2002). To our knowledge, however, the occurrence of Lake Chub has not been previously documented in the area of Labrador east of the George River and north of the Churchill River basin. This likely does not represent the actual distribution of the species, but is reflective of the extensive survey work that has been conducted in the Churchill River drainage relative to more northerly parts of the region. As Lake Chub are not a popular game species or widely utilized as fishing bait, they would also go largely unnoticed by anglers and would therefore likely be documented only if lakes were being surveyed specifically for the purposes of describing the fish fauna.

Materials and Methods

Sites

During the period 2002 through 2008, Lake Chub were captured in seven lakes in northern Labrador (Table 1, Figure 1). These lakes are all situated on a plateau that falls within the Kingurutik–Fraser River ecoregion, extending from the Adlatok River in the south (54.25°N) to Okak Bay in the north (57.75°N) (Bell 2002a) (Figure 1). Elevations of the seven lakes range from approximately 136 m (Konrad Lake) to 519 m (Coady's Pond #2). The area is classified as high subarctic tundra and has little vegetation (Bell 2002a). The regional climate is characterized by short, cool summers and long, cold winters (Lopoukhine et al. 1978), with a mean annual temperature of approximately −5°C and ponds on the plateau remaining ice covered as late as July (Peach 1975). Mean annual precipitation varies from 700 mm in the east to 1000 mm in the west (Peach 1975; Bell 2002a*). Geologically, the area is composed primarily of granite, anorthosite, and gneiss (Sutton 1972). Glacial action occurred from west to east in this region, forming steep valleys. Two types of oligotrophic lakes are common here: small, shallow, irregular ponds which occupy hollows eroded in the bedrock; and larger, rock-basin lakes created by damming that resulted from natural accumulations of glacial and fluvial deposits (Anderson 1985).

TABLE 1. Location of the seven lakes where Lake Chub were recently found. Drainage rivers, surface area, and perimeter of each lake are also reported.

Location	Latitude	Longitude	Drainage	Surface area (km²)	Perimeter (km)
Coady's Pond #2	56.6435°N	63.6271°W	Fraser River	1	9
Coady's Pond #1	56.5217°N	63.8931°W	Kogaluk River	6	40
Ikadlivak Lake	56.3288°N	63.3420°W	Ikadlivak Brook	7	18
Walkabout Lake	56.3277°N	63.1565°W	Ikadlivak Brook	4	26
Konrad Lake	56.2224°N	62.7156°W	Konrad Brook	8	24
Esker Lake	56.4171°N	63.6394°W	Kogaluk River	60	194
Strange Lake	56.2853°N	63.9475°W	Kogaluk River	2	10

[1] Coady's Pond #1 and #2 are location names given to lakes sampled based on maps from Larry Coady, showing rough locations at which his group angled while exploring this section of Labrador (Coady 2008).

TABLE 2. Number of individuals of each species caught in the seven sampled lakes.

Location	*Couesius plumbeus*	*Salvelinus namaycush*	*Salvelinus fontinalis*	*Salvelinus alpinus*	*Catostomus catostomus*	*Prosopium cylindraceum*
Coady's Pond #2	7	25	–	33	–	–
Coady's Pond #1	6	14	1	–	12	–
Ikadlivak Lake	6	78	–	3	51	20
Walkabout Lake	70	86	18	6	95	19
Konrad Lake	9	120	3	8	45	–
Esker Lake	50	96	1	6	213	7
Strange Lake	76	138	–	9	178	42

Lakes containing Lake Chub were fairly shallow, with exposed boulders around much of the shoreline. Some of the largest lakes in the region could have areas of deep water (in the range of 50 to 100 m based on the height of the surrounding land), but lake depth was not measured in these surveys. Lake substrates were mainly mud and sand mixed with larger rocks and boulders, and little or no vegetation observed in the littoral areas. Like many lakes on the plateau, the surveyed lakes tended to be separated from nearby lakes by shallow, boulder-filled streams that may facilitate fish migration between ponds.

Sampling

Two unofficially named lakes, which we will refer to as Coady's Pond #1 and #2 (see Table 1), were fished as part of a sampling program targeting Arctic Charr (*Salvelinus alpinus*) in Labrador. These lakes were sampled in early fall using multimesh Lundgren® gillnets (similar to those described by Hammar and Filipsson (1985)). Gillnets were set perpendicular to the shoreline, with the smallest mesh size oriented closest to shore, and allowed to soak overnight. The five other lakes were sampled as part of a larger climate change study being conducted by the Government of Newfoundland and Labrador. As before, standardized monofilament gillnets with mesh size increasing from 12.7 to 127 mm (bar) by 12.7 mm increments, attached in a series of 15.2 m net panels, were used to sample the lakes. Three nets were set perpendicular to the shore at random locations in each lake and allowed to soak for an average of 4 hours. Length, weight, and sex, as well as date and location of capture, were recorded for all sampled fish (with the exception of Esker Lake). In addition to Lake Chub, Lake Trout (*Salvelinus namaycush*), Longnose Sucker (*Catostomus catostomus*), Arctic Charr, Brook Trout (*Salvelinus fontinalis*), and Round Whitefish (*Prosopium cylindraceum*) were captured in the seven lakes (Table 2).

Results and Discussion

Species Description

Lake Chub were identified using descriptions of the species provided by Scott and Crossman (1973), McPhail and Lindsey (1970), and Stewart and Watkinson (2004). Some of the key distinguishing features of Lake Chub from Labrador included a greenish-brown back, a dark mid-lateral band on the smaller specimens, cycloid scales, threadlike terminal maxillary barbels, and a continuous groove separating the upper lip from the snout. No tubercles were noted on any specimens; however, fish were caught in late summer, presumably after spawning had occurred.

According to Scott and Crossman (1973) and McPhail and Lindsey (1970), Lake Chub consume primarily aquatic insect larvae throughout their range, including chironomid and caddis (*Trichoptera*) species as well as cladocerans, zooplankton, and algae. Stomach contents of the fish from Coady's Pond #1 and Coady's Pond #2 were consistent with this description, including chironomid larvae and insect remains.

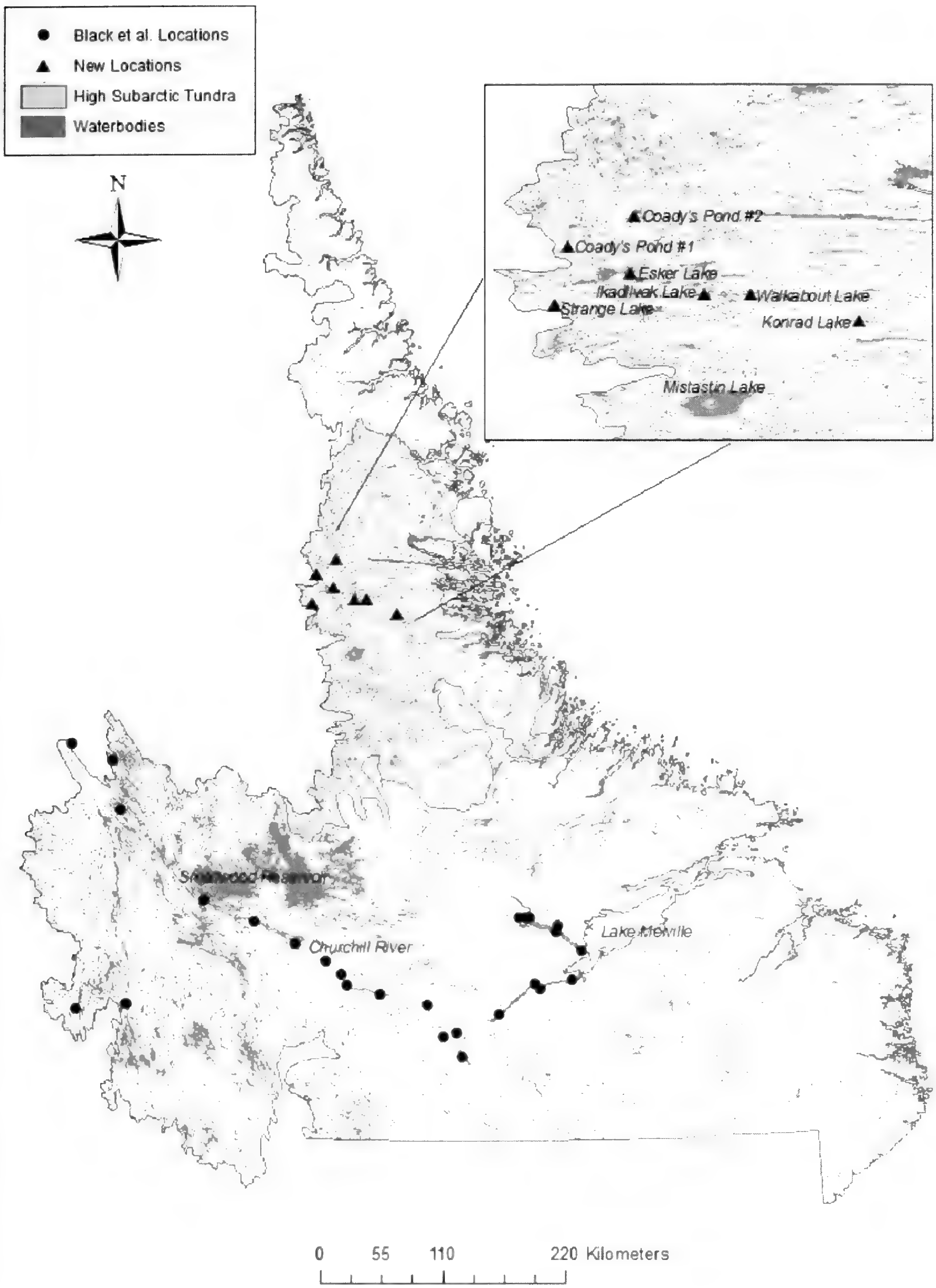


FIGURE 1. Map of Labrador illustrating previously recorded locations for Lake Chub as described by Black et al. (1986) and the seven new locations identified in this study. The Kingurutik–Fraser River ecoregion (high subarctic tundra) is also marked (Bell 2002a*).

TABLE 3. Length (measured as forklength) and weight range of Lake Chub sampled from each lake. This information was not taken for Esker Lake.

Location	Length range (mm)	Weight range (g)
Coady's Pond #2	105–141	14–33
Coady's Pond #1	85–109	7–17
Ikadlivak Lake	102–129	11–23
Walkabout Lake	68–140	3–29
Konrad Lake	90–107	7–11
Esker Lake	–	–
Strange Lake	59–124	1–20

However, small gastropods were also found in the stomachs of two fish from Coady's Pond #2. Carbon and nitrogen stable isotope signatures were obtained for dorsal muscle tissue samples from two individuals from Coady's Pond #2 and from seven individuals from Coady's Pond #1 to further characterize the diet of these populations. All tissue samples were processed according to the methods described in Guiguer et al. (2002). Nitrogen signatures (mean ± SD, Coady's Pond #2: $\delta^{15}N = 7.68 \pm 0.16$; Coady's Pond #1: $\delta^{15}N = 7.04 \pm 0.61$) indicate these fish are secondary consumers (assuming a mean trophic enrichment of approximately 3.4% with each trophic level as reported by Post (2002)), which is consistent with the macroinvertebrate prey items found in stomach contents. Carbon signatures (mean ± SD, Coady's Pond #2: $\delta^{13}C = -21.23 \pm 0.82$; Coady's Pond #1: $\delta^{13}C = -21.33 \pm 0.85$) are consistent with a diet obtained from the littoral food web. Diet information was not available for the five other populations.

Post-glacial Dispersal

As suggested by Black et al. (1986), Lake Chub likely colonized Labrador following the last period of glaciation via an overland route across Quebec. An overland invasion route is more probable than a marine one, given that Lake Chub are a stenohaline species and would therefore not have been able to travel through even brackish water over long distances. It is also unlikely these populations were established as a result of introductions, as there is relatively little human presence, including recreational fishing, in the area. Crossman and McAllister (1986) and Underhill (1986) suggest multiple glacial refugia for Lake Chub in central and eastern North America, including the Atlantic, Mississippian and Missourian refugia. It is therefore likely that Lake Chub dispersed from one or more of these inland refugia and followed various drainages east through the central glacial lakes of the Ungava region. Such a dispersal route could have ultimately led to glacial lakes McLean and Naskaupi, which were formed by the flooding of what is now the George River basin (Jansson 2003). Glacial lake Naskaupi established spillways through cols in the Torngat Mountains watershed, which included an outlet through the Kogaluk River (Ives 1960; Barnett and Peterson 1964; Jansson 2003). Fish following this dispersal route could thus have been able to colonize lakes in the Kogaluk River basin and would have become trapped in lakes on the plateau as Naskaupi and its eastern spillways dried up. Such a colonization route may also explain the apparent absence of Lake Chub between the Kogaluk River and the Churchill River drainages, where there were no known major easterly drainages from Lake Naskaupi during the immediate post-glacial period. However, the presence of fish species within this region is not well documented and further exploration is needed to develop a full understanding of existing distributional patterns and post-glacial colonization routes of freshwater fish species in northern Labrador.

Acknowledgments

We thank D. Keefe and G. Furey for assistance with field collections, K. Miller for assistance with the graphics and manuscript, B. Mark for assistance with the stable isotope analyses, and M. Waldick and one anonymous reviewer for providing comments that greatly improved earlier versions of the manuscript. We would also like to acknowledge L. Coady, who walked across the Labrador barrens and shared with us the locations of lakes in which his expedition caught fish. Funding for this project was provided in part by a Government of Canada International Polar Year Grant (Climate Variability and Change Effects on Charr in the Arctic) and the Government of Newfoundland and Labrador.

Documents Cited (marked * in text)

Bell, T. J. 2002a. Ecoregions of Labrador: Kingurutik/Fraser Rivers. Newfoundland and Labrador Heritage. www.heritage.nf.ca (May 2009).

Literature Cited

Anderson, T. C. 1985. The rivers of Labrador. Canadian Special Publication of Fisheries and Aquatic Sciences 81. 389 pages.

Backus, R. H. 1951. New and rare records of fishes from Labrador. Copeia 1951: 288-294.

Backus, R. H. 1957. The Fishes of Labrador. Bulletin of the American Museum of Natural History 113: 277-337.

Barnett, D. M., and **J. S. Peterson.** 1964. The significance of glacial Lake Naskaupi 2 in the deglaciation of Labrador/Ungava. Canadian Geographer 8: 173-181.

Black, G. A., J. B. Dempson, and **W. J. Bruce.** 1986. Distribution and postglacial dispersal of freshwater fishes of Labrador. Canadian Journal of Zoology 64: 21-31.

Coady, L. W. 2008. The Lost canoe: a Labrador adventure. Nimbus Publishing Ltd., Halifax, Nova Scotia. 243 pages.

Crossman, E. J., and **D. E. McAllister.** 1986. Zoogeography of freshwater fishes of the Hudson Bay drainage, Ungava Bay and the Arctic archipelago. Pages 53-104 *in* Zoogeography of freshwater fishes of North America. *Edited by* C. H. Hocut and E. O. Wiley. John Wiley & Sons, Inc., New York, New York.

Guiguer, K. R. R. A., J. D. Reist, M. Power, and **J. A. Babaluk.** 2002. Using stable isotopes to confirm the trophic ecology of Arctic Charr morphotypes from Lake Hazen, Nunavut, Canada. Journal of Fish Biology 60: 348-362.

Hammar, J. and **O. Filipsson.** 1985. Ecological testfishing with Lundgren gillnets of multiple mesh size: the Drottningholm technique modified for Newfoundland Arctic char populations. Report of the Institute of Freshwater Research Drottningholm 62:12-35.

Harper, F. 1961. Field and historical notes on fresh-water fishes of the Ungava Peninsula and on certain marine fishes of the north shore of the Gulf of St. Lawrence. Journal of the Elisha Mitchell Scientific Society 77: 312-342.

Ives, J. D. 1960. The deglaciation of Labrador-Ungava: an outline. Cahiers de géographie de Québec 4: 323-343.

Jansson, K. N. 2003. Early Holocene glacial lakes and ice marginal retreat pattern in Labrador/Ungava, Canada. Palaeogeography, Palaeoclimatology, Palaeoecology 193: 473-501.

Lopoukhine, N., N. A. Prout, and **E. H. Hirvonen.** 1978. Ecological land classification of Labrador: a reconnaissance. Ecological Land Classification Series (4). Environmental Management Service, Fisheries and Environment Canada, Halifax, Nova Scotia. 85 pages.

McAllister, D. E., and **S. Bleakney.** 1960. Some freshwater fishes from northeastern Quebec and Labrador. Bulletin of the National Museum of Canada 166: 31-39.

McPhail, J. D., and **C. C. Lindsey.** 1970. Freshwater fishes of northwestern Canada and Alaska. Fisheries Research Board of Canada Bulletin 173.

Peach, J. A. 1975. The tourism and outdoor recreation climate of Newfoundland and Labrador. Environment Canada Atmospheric Environmental Service, Toronto. Project Report (20).

Post, D. M. 2002. Using stable isotopes to estimate trophic position: models, methods, and assumptions. Ecology 83: 703-718.

Power, G., and **D. R. Oliver.** 1961. Notes on the distribution and relative abundance of fresh-water fish in Ungava. Canadian Field-Naturalist 75: 221-224.

Power, M., G. M. Klein, K. R. R. A. Guiguer, and **M. K. H. Kwan.** 2002. Mercury accumulation in the fish community of a sub-Arctic lake in relation to trophic position and carbon sources. Journal of Applied Ecology 39: 819-830.

Power, M., G. Power, J. D. Reist, and **R. Bajno.** 2009. Ecological and genetic differentiation among the Arctic charr of Lake Aigneau, northern Québec. Ecology of Freshwater Fish 18: 445-460.

Ryan, P. M. 1980. Fishes of the Lower Churchill River, Labrador. Fisheries and Marine Service Technical Report (922). 189 pages.

Scott, W. B., and **E. J. Crossman.** 1973. Freshwater Fishes of Canada. Fisheries Research Board of Canada Bulletin 184. 966 pages.

Stewart, K., and **D. Watkinson.** 2004. Freshwater Fishes of Manitoba. University of Manitoba Press, Winnipeg, Manitoba. [pages 66-67].

Sutton, J. S. 1972. Notes on the geology of Labrador. Memorial University of Newfoundland. Geological. Report: [pages 5-12].

Underhill, J. C. 1986. The fish fauna of the Laurentian Great Lakes, the St. Lawrence Lowlands, Newfoundland and Labrador. Pages 105-136 *in* Zoogeography of freshwater fishes of North America. *Edited by* C. H. Hocut and E. O. Wiley. John Wiley & Sons, Inc., New York, New York.

Received 6 July 2009
Accepted 14 May 2010

Subarctic Records and Range Extensions of Two Species of Tiger Beetles (Coleoptera: Cicindelidae) in Churchill and Wapusk National Park, Manitoba

Thomas S. Woodcock[1], Peter G. Kevan[1], and Robert E. Roughley[2]

[1]Department of Environmental Biology, University of Guelph, 50 Stone Rd. E., Guelph, Ontario, N1G 2W1 Canada
[2]Department of Entomology, University of Manitoba, Winnipeg, Manitoba, R3T 2N2 Canada
Corresponding Author: Thomas Woodcock; e-mail: twoodcoc@uoguelph.ca

Woodcock, Thomas S., Peter G. Kevan, and Robert E. Roughley. 2010. Subarctic records and range extensions of two species of tiger beetles (Coleoptera: Cicindelidae) in Churchill and Wapusk National Park, Manitoba. Canadian Field-Naturalist 124(2): 118–121.

Two species of tiger beetle (Coleoptera: Cicindelidae) were collected in the vicinity of Churchill, Manitoba and Wapusk National Park. Habitats were dry, sandy areas typically preferred by this family. No tiger beetle has been recorded from this region previously. *Cicindela longilabris longilabris* was collected in two localities, one south of Churchill and another on a relict beach ridge in Wapusk National Park. *Cicindela limbata hyperborea* was collected only on the beach ridge, where adults co-occurred with *C. longilabris longilabris*. These localities represent significant range extensions for both species.

Key Words: *Cicindela longilabris* Say, *Cicindela limbata* Say, Wapusk National Park, beach ridge.

Tiger beetles (order Coleoptera, family Cicindelidae) are attractive, fast-moving, and conspicuous predators of invertebrates in open areas. Over 2000 species are known worldwide and approximately 111 in North America (Pearson and Cassola 1992; Pearson et al. 2005). Most species prefer dry habitats such as sand dunes, rocky outcrops or clay banks (Pearson et al. 2005). Some are known to withstand hypoxic conditions during periodic flooding of their habitat, particularly as larvae (Hoback et al. 1998; Brust and Hoback 2009). The larvae dwell in burrows in the same habitats as the adults, and are also voracious predators of smaller invertebrates. Their interesting biology and the beautiful iridescent colouration of adults make tiger beetles the subjects of a broad base of enthusiasts among professional and amateur naturalists alike, rivalled only by the devotees of Lepidoptera and Odonata. Although many species of tiger beetle are widely distributed, few records exist from northern areas of the world. In this paper, we report the collection of two species of tiger beetles in the Churchill region of northern Manitoba, Canada (Figure 1), an area from which they were previously unrecorded. Collecting insects in the north can be difficult, considering vagaries of weather, dangerous wildlife (polar bears), and remoteness. Sampling in Wapusk National Park requires extensive logistical support, including helicopter travel and bear security personnel, the latter being mandatory for researchers working with Parks Canada in the Churchill region.

The first record for *C. longilabris longilabris* southeast of the town of Churchill, along a sandy road atop the kame between Twin Lakes (15N 452807 UTM 6498079), came from the Arctic & Boreal Entomology Course held in the Churchill region in 2004 (Taki et al. 2005). In 2009, *C. longilabris longilabris* (13.5-14 mm in length; Figure 2A) was taken along the same road on July 7, and on a relict beach ridge in Wapusk National Park (15N 447959 UTM 6381822, Figure 3) on July 12. *C. limbata hyperborea* (11 mm in length; Figure 2B) was also taken on the beach ridge, with adults of the two species active and coexisting in the same area. These records represent significant extensions of the known ranges for both of these species (Pearson et al. 2005). Specimens are deposited at the J. B. Wallis Museum, University of Manitoba.

Although most diverse in warm, dry climates, arctic and subarctic records of tiger beetles are not unknown. *Cicindela longilabris* has a typical boreal distribution, and is known to occur across North America from Newfoundland to northern Alaska, with its northern limit approximating the tree line (Schultz et al. 1992; Pearson et al. 2005). *Cicindela limbata* has several recognized subspecies, formerly including the critically endangered Coral Pink Sand Dunes tiger beetle (*C. l. albissima*) of Utah, which has been elevated to species status by Morgan et al. (2000). Several subspecies occur in northern regions of North America, most commonly on sand dune formations, including the recently described *C. l. nogahabarensis* from an area of sand dunes in Alaska (Knisely et al. 2008), possibly including the Kobuk Sand Dunes (Kobuk Valley National Park) in western Alaska, north of the Arctic Circle (Pearson et al. 2005). *Cicindela oregona guttifera* has also been recorded north of the Arctic Circle in Alaska (Brzoska 2008).

There are two subspecies of *C. limbata* found in Manitoba; *C. limbata limbata* extends into the southwestern part of Manitoba, but *C. limbata hyperborea* is recorded from the extreme northwest of the province

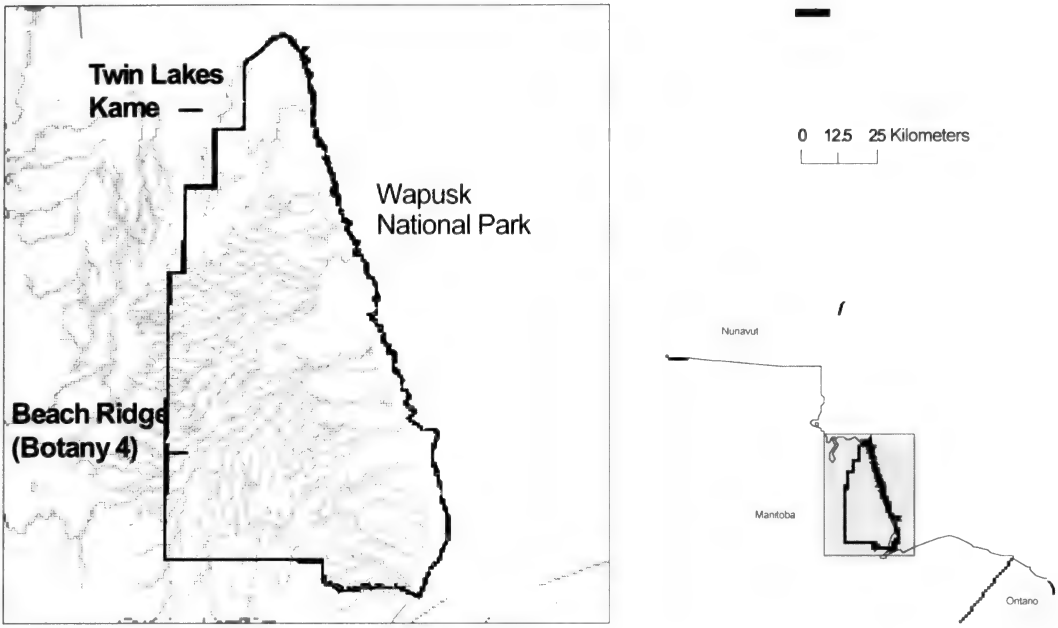


FIGURE 1. Map of the Churchill region and Wapusk National Park, including collection locations of *Cicindela longilabris longilabris* and *C. limbata hyperborea*.

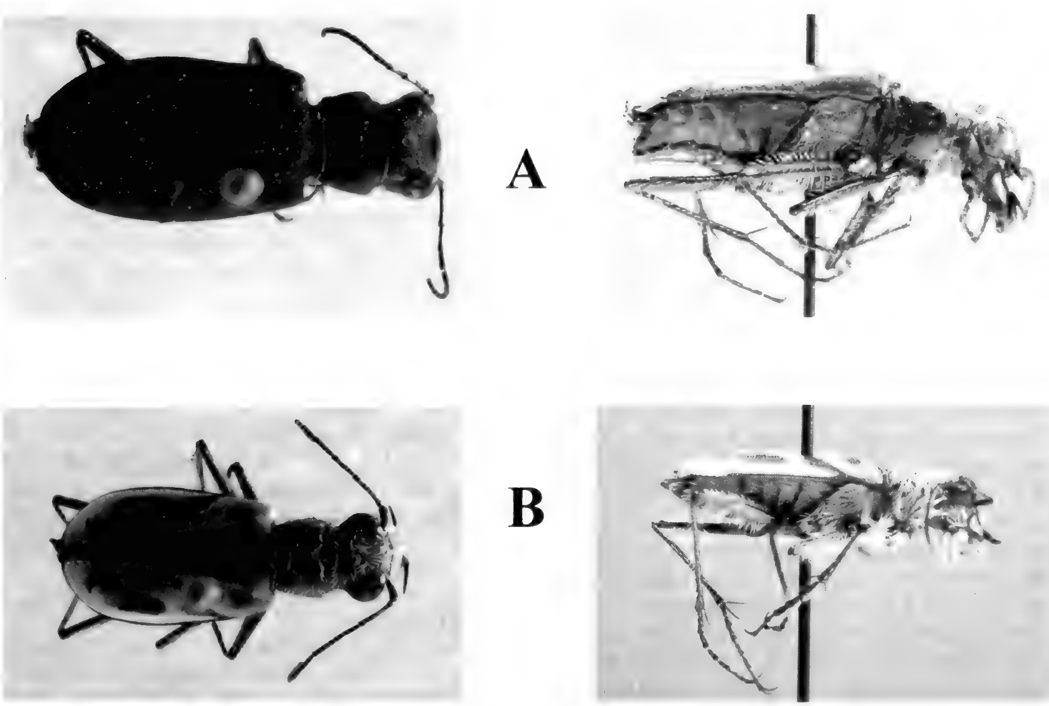


FIGURE 2. Dorsal (left) and lateral (right) views of pinned specimens of *Cicindela longilabris longilabris* (A) and *C. limbata hyperborea* (B) collected in the Churchill region.

FIGURE 3. A relict beach ridge in Wapusk National Park supporting populations of both *Cicindela longilabris longilabris* and *C. limbata hyperborea*.

(Pearson et al. 2005). The latter subspecies was also reported from Goose Bay, Labrador and has been thought to have been introduced to the area by human activity (Larson 1986; Pearson et al. 2005). However, this population has now been assigned to a new subspecies (*C. l. labradorensis*), and is suspected to be a remnant of a broader distribution of *C. limbata* that colonized the area following the glacial retreat (Johnson 1989; Brzoska and Stamatov 2008).

Many tiger beetles are known to be active at high temperatures (Pearson et al. 2005), and their adaptation to thermoregulate effectively by solar basking under such conditions could be a factor in the southerly distribution of most species. Schultz et al. (1992) found that adult *C. longilabris* from populations in different parts of their range were capable of activity at lower temperatures than many species, and may occupy cooler habitats than other species at lower latitudes. Although adults are active only during the summer season, overwintering larvae or pupae require adaptations including tolerance to being frozen. These larvae may take up to three years to reach adulthood in Manitoba (Hamilton 1925). Adults may also need to cope with cold in the summer season. Adults' adaptations may include dark colouration (melanism), as seen in *C. longilabris longilabris* (Figure 2A) and/or hairiness as in *C. limbata hyperborea* (Figure 2B). Several groups of arctic insects, including bumble bees and certain Lepidoptera, have been shown to use dense hairs to conserve metabolic heat and reduce convective heat loss, a strategy that may be particularly effective in concert with melanism (Downes 1965; Danks 2004) and behavioural thermoregulation (Kevan 1989).

Acknowledgments

The authors thank Parks Canada, particularly S. Kowalchuk, J. Larkin, and M. Ratson, for logistical support and field assistance during our collecting efforts in Wapusk National Park. This work was funded in part by an NSERC International Polar Year research grant.

Literature Cited

Brust, M. L., and **W. W. Hoback.** 2009. Hypoxia tolerance in adult and larval *Cicindela* tiger beetles varies by life history but not habitat association. Annals of the Entomological Society of America 102: 462-466.

Brzoska, D. W. 2008. Note on tiger beetles above the Arctic Circle. Cicindela 40: 65-66.

Brzoska, D. W., and **J. Stamatov.** 2008. A trip to Goose Bay, Labrador, Canada. Cicindela 40: 47-52.

Danks, H. V. 2004. Seasonal adaptations in Arctic insects. Integrative and Comparative Biology 44: 85-94.

Downes, J. A. 1965. Adaptations of insects in the Arctic. Annual Review of Entomology 10: 257-274.

Hamilton C. C. 1925. Studies on the morphology, taxonomy and ecology of the larvae of Holarctic tiger beetles (family Cicindelidae). Proceedings of the United States National Museum 65, Article 17: 1-87.

Hoback, W. W., D, W. Stanley, L. G. Higley, and **M. C. Barnhart.** 1998. Survival of immersion and anoxia by larval tiger beetles, *Cicindela togata*. American Midland Naturalist 140: 27-33.

Johnson, W. N. 1989. A new subspecies of *Cicindela limbata* Say from Labrador, Canada (Coleoptera, Cicindelidae). Naturaliste Canadien 116: 261-266.

Kevan, P. G. 1989. Thermoregulation in arctic insects and flowers: Adaptation had co-adaptation in behaviour, anatomy, and physiology. Pages 747-754 *in* Thermal Physiology 1989. *Edited by* J. B. Mercer. Proceedings of the International Symposium on Thermal Physiology, Tromsø, Norway, 16-21 July 1989. Excerpta Medica, Elsevier Science Publishers B.V. The Netherlands.

Knisely, C. B., M. R. Woodcock, and **A. P. Vogler.** 2008. A new subspecies of *Cicindela limbata* (Coleoptera: Cicindelidae) from Alaska, and further review of the *maritima* group by using mitochondrial DNA analysis. Annals of the Entomological Society of America 101: 277-288.

Larson, D. J. 1986. The tiger beetle *Cicindela limbata hyperborea* in Goose Bay, Labrador, Canada (Coleoptera, Cicindelidae). Coleopterists Bulletin 40: 249-250.

Morgan, M., C. B. Knisely, and **A. P. Vogler.** 2000. New taxonomic status of the endangered tiger beetle *Cicindela limbata albissima* (Coleoptera: Cicindelidae): Evidence from mtDNA. Annals of the Entomological Society of America 93: 1108-1115.

Pearson, D. L., and **F. Cassola.** 1992. World-wide species richness patterns of tiger beetles (Coleoptera: Cicindelidae): Indicator taxon for biodiversity and conservation studies. Conservation Biology 6: 376-391.

Pearson, D. L., C. Knisely, and **C. J. Kazilek.** 2005. A Field Guide to the Tiger Beetles of the United States and Canada. Oxford University Press, New York.

Schultz, T. D., M. C. Quinlan, and **N. F. Hadley.** 1992. Preferred body temperature, metabolic physiology, and body temperature of adult *Cicindela longilabris* – a comparison of populations from boreal habitats and climatic refugia. Physiological Zoology 65: 226-242.

Taki, H., P. G. Kevan, and **R. E. Roughley.** 2005. Arctic and boreal entomology course 2004. Bulletin of the Entomological Society of Canada 37: 156-158.

Received 17 October 2009
Accepted 12 April 2010

The Diet of the Eastern Screech-Owl, *Megascops asio,* at the Northern Periphery of its Range

CHRISTIAN ARTUSO

Birds Studies Canada Manitoba Program, Box 24-200 Saulteaux Cr, Winnipeg, Manitoba R3J 3W3; e-mail: cartuso@birds canada.org

Artuso, Christian. 2010. The diet of the Eastern Screech-Owl, *Megascops asio,* at the northern periphery of its range. Canadian Field-Naturalist 124(2): 122–133.

Four techniques: pellet analysis, post-fledging nest inspection, video monitoring, and direct observation were used to study the diet of Eastern Screech-Owl (*Megascops asio*) in Winnipeg, Manitoba, at the northern limit of the species' range. In 2004 – 2007, 2323 prey items were analyzed. Invertebrates comprised 67% of prey captures but only 11% of biomass consumed. Seasonal shifts in diet between biologically significant periods were significant such that multiple discriminant analyses correctly classified 60% of pre-breeding season, 91% of incubation, 67% of brooding, 86% post-fledging and 100% of winter consumption. Rural pairs consumed a higher percentage of invertebrates and fewer vertebrates than suburban pairs. Prey diversity and niche breadth peaked in low-density suburban areas but rural areas and high-density suburbs were similar in terms of niche breadth. Only 37 vertebrate prey species were recorded and the total niche breadth was 6.5, reflective of a higher degree of diet specialization than more southerly populations.

Key Words: Eastern Screech-Owl, *Megascops asio*, raptors, owls, diet, urban ecology, range-peripheral, Manitoba.

The diet of the Eastern Screech-Owl (*Megascops asio*) is comparatively well-studied; however, most studies have utilized only one or two methods such as pellet analysis, identification of prey remains in nest boxes, and stomach contents. These different methods lead to different conclusions about the relative importance of invertebrate versus vertebrate prey (Ritchison and Cavanagh 1992). Of the 11 studies included in Ritchison and Cavanagh's (1992) review, only three examined stomach contents and only one (Allen 1924) contained an observational component. Pellet samples of Eastern Screech-Owl have typically under-reported invertebrates (Errington 1932; Craighead and Craighead 1956) and have shown the percentage of mammals consumed to be very high (Cahn and Kemp 1930; Wilson 1938; Craighead and Craighead 1956; Korschgen and Stuart 1972). Studies of nest box contents also under-reported invertebrates (VanCamp and Henny 1975) and suggested a higher proportion of birds (Stewart 1969, Duly 1979) in the diet. Examination of stomach contents found high predation on invertebrates such as arthropods, especially in the summer months (Fisher 1893; Hanebrink et al 1979; Brown 1989). Duly (1979) found stomach contents contained 93% invertebrates but cached prey only 8% invertebrates. Furthermore, most if not all of these studies under-reported soft-bodied invertebrates such as earthworms which leave no remains in pellets and which are rarely cached (Ritchison and Cavanagh 1992; Artuso 2009). This study aims to give a more comprehensive portrait of the diet of a northern population of Eastern Screech-Owl by using a combination of two observational techniques (direct observation and video recordings) and two non-observational techniques (pellet analysis and nest-box inspection).

In the Winnipeg area, Eastern Screech-Owls reside along the rural – urban gradient and reach their highest densities in suburbs (Artuso 2009). Urbanization can greatly influence the diet of birds, sometimes offering either increased or more varied resources (Botelho and Arrowood 1996; Diermen 1996) and sometimes causing profound changes in dietary regimes (Wolf and del Rio 2000; Faeth et al. 2005). Such resources may be accompanied by increased risks such as pollution, toxins or diseases (Kostelecka-Myrcha et al. 1997; Jensen et al. 2002) and may even result in ecological traps or population sinks (Remes 2000, Battin 2004). I therefore compared the diet of screech-owls in rural, low-density suburban, and high-density suburban areas.

Methods

The study area was a circle with a radius of 40km from the center of Winnipeg, Manitoba, at the northern periphery of the range of Eastern Screech-Owl. This area permitted comparisons across the human density gradient. In this area, 88% of screech-owl nests were found in riparian areas (Artuso 2009). I used four methods to identify prey: field observations, occasionally with the aid of flash photography; video footage from inside a single nest box over two nesting seasons; analysis of pellets; and the inspection of nest boxes after all young had fledged. The sample from the nest with a video camera was supplemented with observational and pellet data. I cross-referenced all prey items so that items observed in the field or video were not double counted in pellets or nest box remains. I also

compared percentages of avian, mammalian and invertebrate prey from the video recordings with those of nearby nests with observational data only to ensure that no biases arose from this single sample. If a prey item was observed being eaten and its remains were later recovered in a pellet or nest box it was treated as observed.

Mammal and bird remains were identified by consulting the collection at the Manitoba Museum and suitable reference material (Banfield 1974; Elbroch and Marks 2001; Kays and Wilson 2002; U.S. National Fish and Wildlife Forensics Laboratory, n.d., Wageningen University Experimental Zoology Group, no date). Invertebrates were identified to family or genus level by examining head capsules, elytra and legs. The number of beetles consumed was calculated from head capsules. Feather remains in nest boxes were always assumed to represent only one individual of each species identified unless the total number of remiges or rectrices exceeded the number found on one bird. Single feathers of Wood Duck (*Aix sponsa*), Northern Flicker (*Colaptes auratus*) and European Starling (*Sturnus vulgaris*) without other remains found in nest boxes were not assumed to be prey as these may have been shed by these birds when visiting the boxes. The mass of each bird species was taken from Sibley (2000), and of mammals as the average of the two values (range) given by Kays and Wilson (2002). The average weight of invertebrate species was calculated from weighing individuals found in the study area. When prey was identified to genus, family, or group only, the average weight of all known members of that group in the sample was calculated and assigned to unidentified items.

Each screech-owl territory was classified as belonging to one of three categories pertaining to human density, measured in persons per hectare (p/ha): high-density suburban (>30 p/ha), low-density suburban (>10 – 30 p/ha), and rural areas (<10 p/ha) (Artuso 2009). These categories refer to human population density rather than habitat or (altered) landscape features per se. As the study area was within one city and surrounding area, habitat was similar throughout. Nonetheless, sites where nests were found within the rural category, as operatively defined here, did have some differences from suburban areas. In particular, the number of trees and canopy cover decreased along the rural – urban gradient at screech-owl nest sites and unused sites, as did shrub density measured directly beneath cavity trees (Artuso 2009). Conversely, the number of coniferous trees (planted by humans) and the number of buildings and amount of impervious surface increased along this gradient (Artuso 2009). Rural sites had more natural cavities whereas suburban sites had more nest boxes. Rural sites also had a slightly different tree composition, such as more trembling aspen, and a denser middle story with a greater percentage of trees in the 5 – 10m height range (as opposed to >10m) than suburban sites. High-density suburban areas often had some high-rise buildings, including condominiums and apartment buildings, but also retained areas of riparian woodland along a river or in smaller parks.

The two broad periods of breeding and non-breeding roughly followed Ritchison and Cavanagh (1992) with an adjustment for the northern location of this study such that the breeding season was treated roughly as April through September or, where known, calculated for individual pairs as the period extending from the onset of incubation until 10 weeks after the fledging date of the oldest chick, which corresponds to typical natal dispersal (Gehlbach 1995). The non-breeding season was thus October through March. Prey consumption was calculated by significant biological period for individual pairs based on back calculation from fledging dates. The typical dates for these periods were: pre-egg laying (1 Mar – 31 Mar), incubating (1 April – 8 May), brooding (9 May – 3 July), post-fledging (4 July – 30 Sept) (Artuso 2009). The "summer" period refers to items collected from nest boxes post-fledging for which the exact time of capture is not known.

I calculated the percentage consumption of mammals, birds, amphibians plus fish, and invertebrates per nest/year. I subdivided bird species consumed into resident and locally breeding species versus winter visitors and passage migrants; mammals into rodents and non-rodents; and invertebrates into hard-bodied (detectable in pellets) versus soft-bodied (only recorded from observations). Niche breadth and overlap were calculated following Gehlbach (1994) for the four prey classes to aid comparison with three other studies (VanCamp and Henny 1975; Turner and Dimmick 1981; Gehlbach 1994; summarized in Gehlbach 1995, Table 1). I calculated the total number of prey species at each site but tallying invertebrates only at the family level with items identified only to genus or group only included if no other member of that group had been tallied as a species. As differences in sample size prevented direct comparison, I divided all species counts by the square root of the sample size to produce a simple prey diversity index. In addition to overall calculations by human density category and biological period, I also calculated the same percentages (proportion of prey type consumed), diversity index and niche breadth for each breeding attempt; i.e., I did not pool data across years for sites where nesting occurred more than once. These data were analyzed with a Chi-square test (Ritchison and Cavanagh 1992) and multiple discriminant analysis (MDA) for differences between biological periods and between high-density suburban, low-density suburban, and rural sites. I examined box plots and log transformed diversity index and arcsine transformed percentage variables as necessary to reduce heteroscedacity before performing the MDA.

TABLE 1. Prey of Eastern Screech-Owl from 2004 to 2008: sources of the data.

	Bird	Mammal	Other V.	Invert.	Rural	Suburb – low	Suburb – high	TOTAL
Observations								
Field obs.	15	24	4	746	97	501	191	789
Video	62	30	4	129	0	0	225	225
Total obs.	77	**54**	**8**	875	**97**	**501**	**416**	**1014 (44%)**
Remains								
Pellets	221	367	0	249	83	586	168	837
Nests	46	8	0	418	317	97	58	472
Total remains	**267**	**375**	**0**	**667**	**400**	**683**	**226**	**1309 (56%)**
TOTAL	**344**	**429**	**8**	**1542**	**497**	**1184**	**642**	**2323**

Other V. refers to amphibians and fish, obs. = observations, Nests refers to the inspection of nest sites after all young had fledged.

Results

I identified 2323 prey items from March 2004 to February 2008 from four sources: field observations ($n = 789$); video footage ($n = 225$); analysis of pellets ($n = 837$); and inspection of nest boxes ($n = 472$) (Table 1). I found 637 pellets, ranging in size from 8 × 4 mm to 51 × 12 mm (but sometimes as much as 20 mm wide in part due to flattening) and averaging 25.4 × 10.5mm. The number of prey items from observations and remains were similar, 1014 (44%) and 1309 (56%) respectively; however, the ratio of observations to pellets was not constant at all sites and care is needed when drawing conclusions about comparative capture rates (Table 1). Eight mammal prey species were recorded. Meadow Vole (*Microtus pennsylvanicus*) was by far the most important individual prey species (63% of mammalian prey and 75% of mammalian biomass). Including 20 unidentified voles, voles constituted 68% of all mammal prey and 81% of the mammalian biomass consumed. Meadow Voles constituted 9% (rural) – 12% (low and high-density suburban) of all prey during breeding and 2% (rural) – 20% (low-density suburban) – 45% (high-density suburban) in the non-breeding season. House Mouse (*Mus musculus*) (13%) and North American Deermouse (*Peromyscus maniculatus*) (6%) were also regular prey. Little Brown Bat (*Myotis lucifugus*) (1%) and Northern Short-tailed Shrew (*Blarina brevicauda*) (1%) were rarely consumed. House Mouse was absent from rural sites and ranged from 3% (low-density suburban) and 2% (high-density suburban) during breeding to 6% (low-density suburban) and 10% (high-density suburban) in the non-breeding season.

A total of 26 bird species were recorded as prey; however, many bird remains could not be identified to species. Birds consumed were largely passerine (82%) and the majority were small species under 40g (55% <20g, 34% 20 – 40g, 11% >40g), contrary to Gehlbach (1994). The most commonly recorded avian prey species were House Sparrow (*Passer domesticus*) (13% of all birds) and Black-capped Chickadee (*Poecile atricapillus*) (9%). House Sparrow was much less common in high-density suburban and rural areas (<1%) than in low-density suburban sites. Yellow-rumped Warbler (*Dendroica coronata*) (3%) was the most commonly captured migrant. The largest avian prey captured were Rock Pigeons (*Columba livia*) and Blue Jays (*Cyanocitta cristata*), as well as a single Virginia Rail (*Rallus limicola*), a species seldom recorded within the city of Winnipeg (personal observations). The only two amphibian prey items confirmed to species were Northern Leopard Frog (*Lithobates pipiens*) and Wood Frog (*Rana sylvatica*) and only a single unidentified fish was found.

Fifty-seven percent of invertebrates consumed were detected using observational techniques, compared to 22% for birds and 13% for mammals. Invertebrates consumed included insects, earthworms, crustaceans, arachnids, gastropods, and many unidentified items. Most invertebrates consumed were insects, and of these beetles were the most common group (43% of invertebrates), presumably because their remains are readily found and identified in pellets and nest boxes. The family Scarabidae constituted 83% of the beetles identified, of which many appeared to be in the genus *Phyllophaga*. After beetles, the next most important invertebrate prey were both soft-bodied, the earthworm *Lumbricus terrestris* (5%) and various caterpillars (4%). Earthworms were most commonly captured in low-density suburban areas (1% of all rural prey in the breeding season, 5% low suburban, 3% high suburban). The proportion of invertebrate prey captured by three unpaired males ($\xi \pm$ SE: 27.3 ± 14.2%) was much lower than for breeding pairs (75.7 ± 5.6%). Unpaired males caught mammals (56 ± 20.9%) more frequently than breeding pairs (12.2 ± 3.8%) (MANOVA, Wilk's Lamba = 0.6, $F = 6.38$, df = 2,19, $P = 0.008$); however, the data on the diets of unpaired males were collected primarily from pellets found at roost sites and are therefore biased due to a lack of observational information.

Despite being unavailable to the owls in winter, invertebrates constituted by far the largest proportion of total prey captures (66% overall, 71% in the breed-

TABLE 2. Prey of Eastern Screech-Owl from 2004 – 2008: prey captures by period.

Period	Bird	Mammal	Amphibian and fish	Invertebrate	Total
Winter	22 (50%)	22 (50%)	0	0	44
Pre-egg laying	68 (38%)	66 (37%)	0	44 (25%)	178
Incubating	82 (19%)	209 (49%)	3 (1%)	131 (31%)	425
Brooding	124 (17%)	110 (15%)	5 (1%)	476 (67%)	715
Post-fledging	25 (5%)	18 (3%)	0	491 (92%)	534
Summer	23 (5%)	4 (1%)	0	400 (94%)	427
Total	**344 (15%)**	**429 (18%)**	**8 (<1%)**	**1542 (66%)**	**2323**

Percentages indicate the number prey in each period against the total number of prey in that period.

TABLE 3. Prey of Eastern Screech-Owl from 2004 – 2008: biomass consumed by period.

Period	Bird	Mammal	Amphibian and fish	Invertebrate	Total
Winter	588g (40%)	878g (60%)	0g	0g	1466g
Pre-egg laying	1710g (39%)	2599g (59%)	0g	91g (2%)	4399g
Incubating	2689g (23%)	8690g (74%)	34g (<1%)	284g (2%)	11697g
Brooding	3419g (37%)	4645g (51%)	85g (1%)	1033g (11%)	9182g
Post-fledging	627g (26%)	719g (30%)	0g	1067g (44%)	2413g
Summer	568g (37%)	167g (11%)	0g	803g (52%)	1537g
Total	**9601g (31%)**	**17698g (58%)**	**119g (<1%)**	**3277g (11%)**	**30695g**

Percentages indicate the total biomass per category in each period against the overall biomass in that period.

ing season, 20% in the non-breeding season) (Table 2). Mammals are the next highest group (18% overall, 16% breeding, 40% non-breeding) but only slightly higher than birds (15% overall, 12% breeding, 40% non-breeding). Amphibians and fish, which are also unavailable to the owls in winter, were a very small component (<1% overall). The number of birds, mammals, amphibians and fish, and invertebrates consumed (Table 2) varied significantly by biological period ($\chi^2 = 854.3$, df = 15, $P < 0.001$). Mammals were captured more than birds overall; however, birds and mammals were consumed in equal proportions in the non-breeding season (Mammals captured: 16% breeding, 40% non-breeding, 50% winter only; birds captured: 12% breeding, 40% non-breeding, 50% winter only). Despite the high percentages of invertebrates captured, invertebrates constituted only 11% of the biomass consumed (13% breeding, 2% non-breeding) (Table 3). Although their capture rates were only slightly higher, mammals contributed much more to biomass consumed than birds (58% versus 31% overall, 57% versus 29% breeding, 59% versus 40% non-breeding). The ratio of vertebrates to invertebrates did not vary by year ($\chi^2 = 0.36$, df = 3, $P = 0.95$); however, there was annual variation in the type of invertebrates consumed, for example, earthworms were highest in the wettest year (17% of invertebrate captures in 2004 when precipitation from March – September totaled 531mm down to zero in 2006 when March – September precipitation was only 231mm) (Environment Canada, no date.).

The MDA comparison of prey type by period (not including the unspecified summer period) identified two significant axes, viz. canonical 1: canonical correlation = 0.91, likelihood ratio = 0.03, $F = 3.57$, df = 48, 113.75, $P < 0.001$ and canonical 2: canonical correlation = 0.84, likelihood ratio = 0.17, $F = 2.21$, df = 33, 89.09, $p = 0.001$ (Table 4). The MDA correctly classified 60% of the pre-breeding period, 91% of the incubation period, 67% of the brooding period, 86% of the post-fledging period, and 100% of the winter period. The first two canonical axes from the MDA (Figure 1.) show strong separation of the diet in biologically significant periods, primarily by the distribution of the prey classes and diversity. Canonical axis 1 is highly correlated to percent mammals (0.85, total canonical structure) and birds (0.78) and negatively correlated to percent invertebrates (-0.96). Within the prey classes, this axis was correlated strongly to rodents (0.54) and negatively to soft-bodied invertebrates (-0.51). Niche breadth (0.54) and prey diversity (0.47) were also important. Canonical axis one therefore represents a gradient of increasing vertebrate and decreasing invertebrate consumption (especially soft-bodied invertebrates) and the winter and pre-breeding periods thus score highest (Figure 1). Canonical axis 2 was strongly correlated with hard-bodied invertebrates (0.6), niche breadth (0.47), non-rodents (0.39), amphibians and fish (0.31), mammals (0.31), and diversity (0.26). It was negatively correlated to birds (-0.13), in particular resident birds (-0.19). Canonical axis 2 is thus a gradient of increasing mammal consumption, including increasing diversity of mammals (addition of non-rodents) and higher niche breadth but slightly lower bird consumption, in particular fewer migratory species. Accordingly the incubation and brooding peri-

TABLE 4. Total canonical structure from MDA for prey type differences between biologically significant periods and human density categories.

	By Period		By Human Density Category	
	Canonical 1	Canonical 2	Canonical 1	Canonical 2
Birds †	0.34	2.24	0.25	0.6
Resident birds †	-0.36	-0.32	0.11	-0.15
Migrant birds †	-0.08	-0.04	0.41	0.09
Mammals †	-0.47	4.07	0.5	-0.05
Rodents †	0.07	-0.31	0.5	0.06
Non-rodents †	0.54	0.18	0.14	0.38
Amphibian/ fish	0.26	0.90	0.23	-0.2
Invertebrates †	-1.62	3.85	-0.46	-0.03
Hard bodied †	0.14	0.30	0.31	0.34
Soft bodied †	0.24	0.53	-0.12	0.23
Diversity §	-0.68	-0.41	0.3	0.58
Niche breadth	-0.06	-0.38	0.18	0.5

§ indicated that the variable was log transformed. † indicates the arcsine transformation.

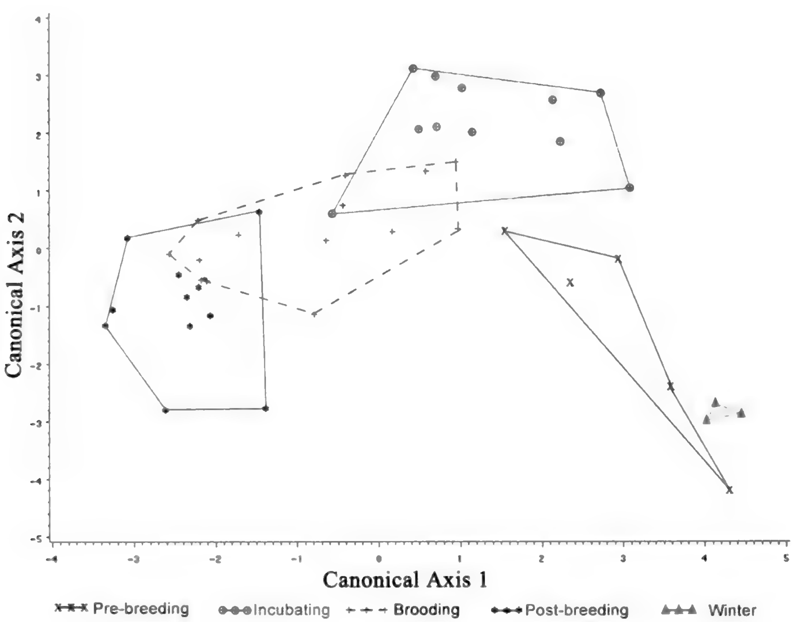


FIGURE 1. Scatter plot of canonical 1 and 2 scores from MDA for prey types differences between biologically significant periods.

ods scored highest on this axis, whereas the winter and pre-breeding periods scored lowest (Figure 1).

The percentages of birds, mammals, amphibians and fish, and invertebrates consumed overall differed between rural, low-density suburban and high-density suburban sites ($\chi^2 = 17.2$, df = 6, $P = 0.008$) (Table 5). Owls on rural sites consumed fewer birds than owls in low and high-density suburban sites in both the breeding and non-breeding seasons (9% fewer than low-density suburban owls in the breeding season and 30% fewer in the non-breeding season). The ratio of resident and locally breeding species to passage migrant and non-breeding visitors was approximately 2:1 on all sites (Table 5). Owls on low-density suburban sites consumed almost double the amount of birds in the non-breeding season as owls in high-density sites and triple that of birds in rural sites. Owls in rural areas consumed fewer mammals in the breeding season than either group of suburban owls. However, owls in high-density suburban areas consumed more mammals in the non-breeding season. Mammalian diversity in the diet was greater on low-density suburban sites, there being no shrews or bats consumed anywhere else. Owls on rural sites consumed 16% more invertebrates

TABLE 5. Percentage prey distribution, diversity and niche breadth in breeding (Br) and non-breeding (Non-br) seasons by human density category.

	Rural		Suburban – low		Suburban – high	
	Br	Non-br	Br	Non-br	Br	Non-br
Total sample size	490	7	998	186	613	29
Birds	**4.3**	**14.3**	**12.9**	**44.1**	**17.0**	**24.1**
Resident birds	66.7	100.0	63.2	70.3	65.9	83.3
Migrant birds	33.3	0.0	36.8	29.7	34.1	16.7
Mammals	**10.6**	**42.9**	**18.0**	**33.9**	**17.8**	**75.9**
Rodents	100.0	100.0	92.6	96.7	100.0	100.0
Non-rodents	0.0	0.0	5.1	3.3	0.0	0.0
Amphibians and fish	**0.4**	**0.0**	**0.3**	**0.0**	**0.7**	**0.0**
Invertebrates	**84.7**	**42.9**	**68.7**	**22.0**	**64.6**	**0.0**
Hard bodied	94.9	0.0	66.1	85.0	65.5	0.0
Soft bodied	4.8	100.0	33.3	15.0	33.1	0.0
Average prey sp/site	14.0	4.0	15.2	10.5	11.3	7.0
Niche breadth – class	1.4	2.6	1.9	2.8	2.1	1.6
Niche breadth – species	2.2	4.5	6.1	12.4	4.9	3.8

Percentages of birds, mammals, amphibians and fish, and invertebrates are calculated against the total number of prey items for each of the three human density categories. Other percentages are of against the total number of birds, mammals, or invertebrates that could be identified to species or genus level and were thus classifiable into subgroups.

than low-density suburban owls, 20% more than high-density suburban owls in the breeding season, and 21% and 43% more respectively in the non-breeding season ($\chi^2 = 27.6$, df = 2, $P < 0.001$). Rural owls also consumed a higher proportion of hard-bodied invertebrates and fewer earthworms and caterpillars. Prey species diversity and overall niche breadth was highest at low-density suburban sites. Rural sites had higher diversity in the breeding season than high-density suburbs and vice-versa in the non-breeding season. Niche breadth was higher overall in high-density suburbs compared to rural areas but only marginally. Seasonal differences in niche breadth in these categories reflect smaller sample sizes.

The MDA comparison of prey type among rural, low-density suburban, and high-density suburban sites identified one significant axis and one non-significant axis, viz. canonical 1: canonical correlation = 0.94, likelihood ratio = 0.05, F = 2.58, df = 24, 18, P = 0.02 and canonical 2: canonical correlation = 0.76, likelihood ratio = 0.42, F = 1.26, df = 11, 10, P = 0.36. The MDA correctly classified 100% of rural sites, 100% of low-density suburban sites and 100% of high-density suburban sites. The first canonical axis from the MDA (Table 4, Figure 2.) shows strong separation of the diet between rural, low-density suburban, and high-density suburban sites. Canonical axis 1 is correlated to the percentage of mammals consumed (0.5), in particular rodents (0.5); the percentage of birds consumed (0.25), in particular passage migrants and winter visitors (0.41); and amphibians and fish (0.23). It is also correlated with prey diversity (0.3). This axis is strongly negatively correlated with invertebrate consumption (-0.46). Canonical axis 1 is thus a gradient of decreasing invertebrate consumption and correspondingly higher vertebrate consumption (as per-

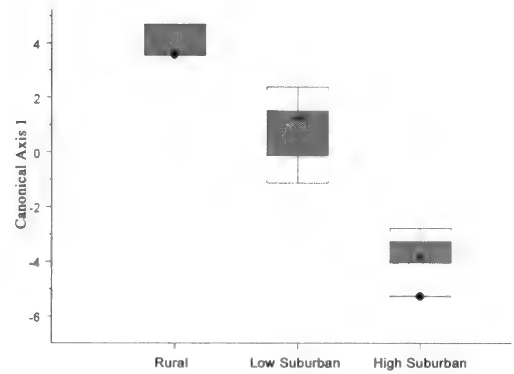


FIGURE 2. Box plot of canonical 1 scores from MDA for prey types differences between rural, low-density suburban and high-density suburban sites.

centages). Since the diversity of invertebrates was only measured to the family level, the higher diversity score on this axis is mostly explained by vertebrates. Rural sites scored highest on this axis; i.e., high invertebrate consumption and low vertebrate consumption, and high-density suburban sites the lowest (Figure 2).

The total niche breadth calculated by species (B) for this study was 6.5; however, the true niche breadth is higher because some diversity is masked by unidentified birds and invertebrates. To facilitate a comparison between studies, I removed invertebrates except crayfish (following Gehlbach 1994) leaving 38 species (some identified only to genus) and a niche breadth of 5.9, much lower than Ohio (69 spp, B = 16.6, VanCamp and Henny 1975) and Texas (72 spp, B = 18.0, Gehlbach 1994). The niche overlap between Manitoba and Ohio (VanCamp and Henny 1975, Table 2) is

0.7 (70%), much higher than the overlap between Manitoba and Texas of 0.21 (21%) (Figure 3). The niche overlap between Ohio and Texas was 0.31 (Gehlbach 1994). A recent study in Québec identified 26 prey items and a niche breadth of only 3.4 (Richards et al. 2006, Table 5); however diet was not the authors' focus and the only method used was periodic inspection of nest boxes. Almost no invertebrates were recorded in Québec due to methodology, so I calculated niche overlap with Manitoba excluding invertebrates as 0.87, indicating substantial similarities in mammalian and avian prey. Across seven studies where sufficient information on prey composition was provided, there is a non-significant decrease in niche breadth with increasing latitude (linear regression: $t = 3.47$, df = 5, $P = 0.09$, $R^2 = 0.46$, Figure 3). This trend would likely be significant with greater consistency in methods and sample sizes.

Some species were found as prey in several studies, although their relative importance differed. Peculiar was the absence of Mourning Dove (*Zenaida macroura*) as a prey item because this species was frequently consumed in other studies at northern locations (VanCamp and Henny 1975; Richards et al. 2006). The Meadow Vole is particularly important in northern diets (68% of mammals, 13% overall and 32% of all winter captures in Manitoba; 75% of mammals and 52% overall in Québec; and 37% of mammals, 13% overall and 23% of all captures in the non-breeding season in Ohio). The degree of specialization in Manitoba is comparatively high for a generalist predator, with the three most frequently consumed mammals (Meadow Vole, House Mouse, Deermouse) comprising at least 86% of mammalian prey (the true percentage may be higher because some prey were not identified to species and if these are excluded is 97%), and the top three birds (House Sparrow, Black-capped Chickadee, and either Cedar Waxwing or Yellow-rumped Warbler) 23% of avian prey or 48% of avian prey identified to species. These percentages are higher than Ohio (top three mammals 85%, top 3 birds 32%) and Texas (76%, 39%).

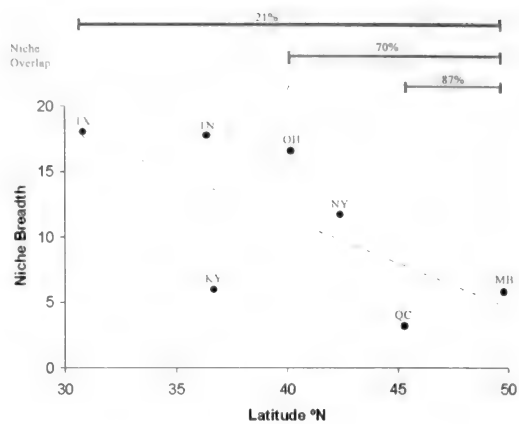


FIGURE 3. Niche breadth (vertebrates and crayfish only) versus latitude from seven studies with niche overlap between Manitoba and Québec, Ohio, and Texas. Data from Manitoba (this study), Québec (Richards et al. 2006), New York (Allen 1924), Ohio (VanCamp and Henny 1975), Kentucky (Ritchison and Cavanagh 1992), Tennessee (Duly 1979), and Texas (Gehlbach 1994).

Discussion

The high percentage of invertebrates in the diet of the Eastern Screech-Owl and the fact that 57% of invertebrates were detected using observational techniques demonstrate the need for observation in assessing prey ratios of generalist raptors. The high consumption rate of invertebrates I recorded in the breeding season has only been matched by studies examining stomach contents (Duly 1979, Hanebrink et al. 1979; Brown 1989). Biases in pellet data have been demonstrated in other owls (Plumpton and Lutz 1993, Yom-Tov and Wool 1997; York et al. 2002). Nonetheless, soft-bodied invertebrates, such as moths, worms and caterpillars, recorded almost only by observation, may be under-reported even in this study with multiple methods. Invertebrates are by far the most common prey during breeding, despite their relatively small contribution to biomass consumed, whereas birds and mammals become more common in the non-breeding season. This pattern is also found in southern parts of the range (Gehlbach 1994, 1995). The Eastern Screech-Owl has a higher hunting success rate for invertebrates (Abbruzzese and Ritchison 1997) and invertebrates are important for the provisioning of broods, even though they contribute comparatively little biomass, as they can be captured close to the nest and delivered frequently, as often as every 45 seconds in some cases (personal observation). Unpaired males apparently capture larger prey items more regularly and rely less on invertebrate prey than breeding pairs, although limited observational data for unpaired males means this result must be interpreted with care. Variation in the type of invertebrates consumed by year, for example, the ratio of earthworms to beetles, is likely due to accessibility at the surface related to factors including humidity, soil moisture and annual variation in precipitation (Gehlbach 1994).

Screech-owls caught crayfish (0.5% of prey captures) and frogs in shallow water; however, fish constituted a smaller proportion of the diet in the study area than elsewhere, with only a single unidentified fish found in this sample, constituting 0.05% of total prey capture in Manitoba versus 1.3% of prey capture in Kentucky (Ritchison and Cavanagh 1992), 2.1% in Texas (Gehlbach 1994), and 3.5% in Ohio (Van Camp and Henny 1975). As 88% of nests were within 500m of a river of creek (Artuso 2009), it remains unclear why this is the case.

Niche breadth calculations suggest very different diets in the northern and southern portions of the range of Eastern Screech-Owl, with narrower niches and greater specialization in the north. This northward gradient of specialization is also found in other owls, for example, Boreal Owls in Finland (Korpimäki 1986), whose total niche breadth in western Finland at 63°N is only 4.4 (from 40 species of avian and mammalian prey) and whose 3 most frequently consumed mammal species comprise 80% and the top three bird species 59% (Korpimäki 1988, calculated by Gehlbach 1994). The Long-eared Owl (*Asio otus*), often described as a diet specialist, also has a more diverse diet in southern locations (Bertolino et al. 2001). In terms of niche breadth and diet specialization, Manitoban Eastern Screech-Owls, with their high consumption of meadow voles and a few common bird species, are more similar to Finnish Boreal Owls than their Texan conspecifics. The Meadow Vole appears to be particularly important in this northern area. Meadow Voles were more commonly captured in suburban areas (9.5% of all captured prey in rural areas, 13.2% in low density suburbs and 13.9% in high-density suburbs). The trend of decreasing niche breadth with increasing latitude (Figure 3), suggests that this pattern of specialization is driven by the lower diversity of prey types available at northern latitudes. Nonetheless, caution is required in interpreting these results because of differences in methodology between different studies, in particular concerning calculating the consumption rate of invertebrate prey.

Eastern Screech-Owls shift their diet with seasonal availability. Invertebrates consumption increases steadily from pre-laying period to the post-fledging period. Conversely, mammals steadily decline in importance through the breeding season. Although mammals, in particular rodents, were captured more than birds and contributed more to the biomass overall, birds became increasingly important in late fall and winter. Mazur (1992) also reported birds and mammals in equal proportions in the late fall. Birds were also consumed in much higher percentages during the non-breeding season than the breeding season in Texas (Gehlbach 1994) but were only slightly higher in Tennessee (Turner and Dimmick 1981) and Kentucky (Ritchison and Cavanagh 1992) and decreased sharply in Ohio (VanCamp and Henny 1975) and Michigan (Craighead and Craighead 1956). Based on the latter two studies and Allen (1924), Ritchison and Cavanagh (1992) concluded that birds were consumed more frequently in the breeding season at northern locations due to an influx of migrants. This is not supported by this study; however, there is support for VanCamp and Henny's (1975) suggestion that avian prey increases with the arrival of spring migrants, viz. birds were taken less than mammals in the incubation period (19% versus 49%) but became dominant over mammals in the brooding period (17% versus 15%) when the peak arrival of Neotropical migrants occurs, and remained slightly higher in the post-fledging period (5% versus 3%). Among avian prey, the percentage of migrants increased in the breeding season and passage migrants had higher Jacob's selectivity indices than resident and locally breeding species (Artuso 2009). The greater importance of avian prey in the winter in Manitoba may be due to accessibility with increasing snow cover. Screech-owls have symmetrical ears and use vision in hunting and are less adapted to the snow-plunging technique of boreal forest species such as the similar-sized Boreal Owl (*Aegolius funereus*) with asymmetrical ears (Gehlbach 1995). Instead screech-owls in Manitoba hunt mammals in winter at the base of large coniferous trees where snow cover is reduced or when they surface, for example, near bird feeders with fallen seed or when traveling between subnivean tunnels, crossing areas such as driveways where snow has been cleared. House Sparrows and other shrub roosting birds are often hunted by flushing them from roosts.

Screech-owls consumed more invertebrates in rural areas than suburbs, as in Texas during the breeding season (Gehlbach 1994). On the contrary, Burrowing Owls (*Athene cunicularia*) consume more aerial insects at urban sites than rural sites in Florida (Chipman et al. 2008). Earthworms were most frequently captured in low density-suburbs, presumably because the only species recorded, *Lumbricus terrestris,* is associated with human activity (Reynolds 2000). In addition, the watering of lawns at night with sprinkler systems may provide greater access to earthworms in suburbs. Consumption of invertebrates began as much as two weeks earlier in suburbs with the first invertebrate prey being recorded on 30 March as opposed to 16 April in rural areas (earliest dates all occurred in 2007), although the smaller sample size in rural areas meant a reduced likelihood of detecting early invertebrate captures there (Table 1). The percentage of invertebrates captured in March and April against total invertebrate capture was 1% in rural areas, 10% in low-density suburban and 4% in high-density suburban areas. Although the earlier availability of invertebrate prey is unlikely to be the sole factor permitting earlier nesting in the suburbs, there are additional dietary benefits to early nesting in that recently fledged young who leave the nest on average 5 days earlier in suburban areas than rural areas (Artuso 2009), would have increased availability of avian passage migrants. The earlier availability of invertebrate prey in suburban areas may be related to factors including snow clearance, fertilized gardens, or the urban heat island, which also increases invertebrate diversity in cold climates (Deichsel 2006).

The higher diversity of prey in the non-breeding season in suburbs may relate to the presence of bird species that, despite being uncommon in urban areas in summer, linger or overwinter in the city due in part

to the urban heat island, regularly replenished anthropogenic food sources, and possibly also due to the protective benefits of planted conifers (Taylor and Koes 1995). Such birds may also be concentrated in small areas with reliable food sources, increasing their accessibility to owls. Species such as Dark-eyed Junco (*Junco hyemalis*) and White-throated Sparrow (*Zonatrichia albicollis*), as well as several other Emberizidae and Fringillidae species that are scarce in winter are most likely to occur around feeders and often in suburban and urban areas (Taylor and Koes 1995). Nonetheless, contrary to the generalized remarks of Gehlbach (1995), high-density suburban owls in Winnipeg consumed by far the greatest percentage of mammals in the non-breeding season (76%), and despite having the highest niche breadth by class in the breeding season, had the lowest niche breadth by class in the non-breeding season because of the dominance of rodents in the diet and the absence of invertebrates (niche breadth is highest when all prey classes are in equal proportions). The fact that niche breadths by class are higher in the non-breeding than breeding season in both rural and low-density suburban areas may relate to the seasonal shifts in diet which render the prey classes less evenly distributed, in particular that invertebrates are nearly 4 times higher than the next nearest class (mammals) in low-density suburban areas and nearly eight times higher in rural areas in the breeding season.

Several prey species were less frequently captured in rural areas. House Sparrow, the only avian species to compose >10% of birds captured, was most frequently captured in low-density suburbs. This species roosts in dense shrubbery, often close to buildings or near feeders or grain sources (Lowther and Cink 2006), and suburbs offer concentrations of them. Tawny Owls (*Strix aluco*) take advantage of easy access to avian prey at urban roost sites and increase the proportion of birds in their diet in urban areas (Galeotti 1991). The House Mouse was absent from rural diets and the Meadow Vole was most common in suburbs. Those species were the two most significant individual prey items in terms of biomass consumed and were particularly important in the non-breeding season. If these capture rates are reflective of either availability or access then their apparent increased abundance in suburbs would convey an advantage. As the House Mouse in North America is the commensal form that lives mostly in buildings (Banfield 1974), increased availability in suburbs is not surprising. Meadow Voles may be more common in suburban riparian parks than in riparian forest (Mahan and O'Connell 2005) and their density can increase with cottage development (Racey and Euler 1982). With their small home ranges, rodents can thrive in disturbed suburban habitats (Dickman and Doncaster 1987, Nilon and VanDruff 1987); however, rodent diversity declines with increasing amount of impervious surface and bare ground (VanDruff and Rowse 1986). Like Meadow Voles, some other small mammal species such as the Northern Short-tailed Shrew (*Blarina brevicauda*) are most likely to occur at intermediate disturbance levels (Racey and Euler 1982) and in this study were only found at suburban sites. Small mammal abundance is often higher in small urban patches (Ekernas and Mertes 2006), a phenomenon that may be related to limited dispersal (Barko et al. 2003). This suggests that low-density suburbs may offer the most diversity and abundance of prey species (Blair 1996) and the wider niche breadth and prey diversity of suburban screech-owls therefore reflects availability. Likewise, Burrowing Owls in Florida enjoyed higher prey densities close to buildings (Millsap and Bear 2000). Access to rodent prey in suburbs may also be higher due to nocturnal feeding on fallen seed under bird feeders, snow clearance, and the greater number of coniferous trees under which little snow accumulates (Artuso 2009).

The dietary regime of the Eastern Screech-Owl at the northern periphery of its range is similar in overall composition to the diets of southerly populations. Nonetheless, niche breadth and prey diversity decrease northward corresponding to availability and seasonal shifts in invertebrate versus vertebrate consumption appear more marked. Suburban areas offered a more diverse diet than rural areas, especially in biologically stressful periods; however, niche breadth and diversity peaked in low-density suburbs and declined as human density increased above 30 p/ha.

Acknowledgments

Funding was provided by The Special Conservation Fund of Manitoba Conservation, Manitoba Hydro, The Winnipeg Foundation, the Great Gray Owl Fund administered by R. W. Nero, and a donation by Pat Cooper. I thank Robert Roughley, Terry Galloway and Richard Westwood for their assistance in identifying invertebrate prey. I thank Richard K. Baydack, Brigitte De March, James R. Duncan, Frederick R. Gehlbach, Nicola Koper, Erkki Korpimäki, Peter Taylor, and Merlin W. Shoesmith for their thoughtful comments which improved this manuscript.

Literature Cited

Abbruzzese, C. M., and **G. Ritchison.** 1997. The hunting behavior of Eastern Screech-owls *(Otus asio)*. Pages 21-32 *in* Biology and conservation of owls of the Northern Hemisphere. *Edited by* J. R. Duncan, D. H. Johnson and T. H. Nicholls. North Central Research Station, U.S. Department of Agriculture, St. Paul, Minnesota, U.S.A.

Allen, A. A. 1924. A contribution to the life history and economic status of the screech owl (*Otus asio*). Auk 41: 1-17.

Artuso C. 2009. Life on the Edge: The Eastern Screech-Owl in Winnipeg. Ph.D. dissertation, University of Manitoba, Winnipeg.

Banfield, A. W. F. 1974. The mammals of Canada. University of Toronto Press, Toronto, Ontario, Canada.

Barko, V. A., G. A. Feldhamer, M. C. Nicholson, and **D. K. Davie.** 2003. Urban habitat: A determinant of white-foot-

ed mouse (*Peromyscus leucopus*) abundance in southern Illinois. Southeastern Naturalist 2: 369-376.

Battin, J. 2004. When good animals love bad habitats: Ecological traps and the conservation of animal populations. Conservation Biology 18: 1482-1491.

Bertolino, S., E. Ghiberti, and **A. Perrone.** 2001. Feeding ecology of the long-eared owl (*Asio otus*) in northern Italy: is it a dietary specialist? Canadian Journal of Zoology 79: 2192–2198.

Blair, R. B. 1996. Land use and avian species diversity along an urban gradient. Ecological Applications 6: 506-519.

Botelho, E. S., and **P. C. Arrowood.** 1996. Nesting success of western Burrowing Owls in natural and human-altered environments. Pages 61-68 *in* Raptors in human landscapes: adaptations to built and cultivated environments. *Edited by* D. M. Bird, D. E. Varland and J. J. Negro. Academic Press, London, U.K.

Brown, R. K. 1989. Food habits of Kentucky owls. Kentucky Warbler 65: 38–48.

Cahn, A. R., and **J. T. Kemp.** 1930. On the food of certain owls in east-central Illinois. Auk 47: 323-328.

Chipman, E. D., N. E. McIntyre, R. E. Strauss, M. C. Wallace, J. D. Ray, and **C. W. Boal.** 2008. Effects of human land use on western Burrowing Owl foraging and activity budgets. Journal of Raptor Research 42: 87-98.

Craighead J. J., and **F. C. Craighead.** 1956. Hawks, owls, and wildlife. Stackpole Company, Harrisburg, Pennsylvania, USA.

Deichsel, R. 2006. Species change in an urban setting—ground and rove beetles (Coleoptera: Carabidae and Staphylinidae) in Berlin. Urban Ecosystems 9: 161-178.

Dickman, C.R., and **C. P. Doncaster.** 1987. The ecology of small mammals in urban habitats. Volume 1. Populations in a patchy environment. Journal of Animal Ecology 56: 629–640.

Diermen, J. 1996. Sparrowhawk (*Accipiter nisus*) breeding in village, rural landscape and forest. De Levende Matuur 97: 43-51.

Duly, L. J. 1979. Life history aspects of the screech owl (*Otus asio*) in Tennessee. Thesis, University of Tennessee, Knoxville, Tennessee, U.S.A.

Ekernas, L. S., and **K. J. Mertes.** 2006. The influence of urbanization, patch size, and habitat type on small mammal communities in the New York Metropolitan Region. WildMetro, New York, New York, USA.

Elbroch, M., and **E. Marks.** 2001. Bird tracks and sign. Stackpole, Mechanicsburg, Pennsylvania, USA. Environment Canada. Weather Pages. Retrieved December 2008 from: http://weatheroffice.ec.gc.ca.

Errington, P. L. 1932. Food habits in southern Wisconsin raptors. Part I. Owls. Condor 34: 176-186.

Faeth, S. H., P. S. Warren, E. Shochat, and **W. Marussich.** 2005. Trophic dynamics in urban communities. BioScience 55: 399-407.

Fisher, A. K. 1893. Hawks and owls of the U.S. U.S. Department of Agriculture, Division of Ornithology and Mammalogy Bulletin 3: 163-174.

Galeotti, P. 1991. Feeding ecology of the tawny owls (*Strix aluco*) in urban habitats (northern Italy). Bolletino di Zoologia 58: 143-150.

Gehlbach, F. R. 1994. The Eastern Screech Owl: Life history, ecology, and behavior in the suburbs and countryside. Texas A&M University Press, College Station, Texas, U.S.A.

Gehlbach, F. R. 1995. Eastern Screech-Owl. Account 165 *in* The Birds of North America. *Edited by* A. Poole and F. Gill. American Ornithological Union and the Academy of Natural Sciences of Philadelphia, Philadelphia, Pennsylvania, U.S.A.

Hanebrink, E. L., A. F. Posey, and **K. Sutton.** 1979. A note on the food habits of selected raptors from northeastern Arkansas. Arkansas Academy of Science Proceedings 33: 79-80.

Jensen, K. H., S. Rauch, G. M. Morrison, and **P. Lindberg.** 2002. Platinum group elements in the feathers of raptors and their prey. Archives of Environmental Contamination and Toxicology 42: 338-347.

Kays, R. W., and **D. E. Wilson.** 2002. Mammals of North America. Princeton Field Guides. Princeton University Press, New Jersey, USA.

Korpimäki, E. 1986. Gradients in population fluctuation of Tengmalm's owl *Aegolius funereus* in Europe. Oecologia 69: 195-201.

Korpimäki, E. 1988. Diet of breeding Tengmalm's owl *Aegolius funereus*: long-term changes and year to year variation under cyclic food conditions. Ornis Fennica 65: 21-30.

Korschgen, L. J., and **H. B. Stuart.** 1972. Twenty years of avian predator-small mammal relationships in Missouri. Journal of Wildlife Management 36: 269-282.

Kostelecka-Myrcha, A., J. Zukowski, and **E. Oksiejczuk.** 1997. Changes in the red blood indices during nestling development of the Tree Sparrow (*Passer montanus)* in an urban environment. Ibis 139: 92-96.

Lowther, P. E., and **C. L. Cink.** 2006. House Sparrow (*Passer domesticus*), The Birds of North America Online. *Edited by* A. Poole. Ithaca: Cornell Lab of Ornithology; Retrieved September 2008 from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/012doi: 10.2173/bna.12.

Mahan, C. G., and **T. J. O'Connell.** 2005. Small mammal use of suburban and urban parks in central Pennsylvania. Northeastern Naturalist 12: 307-314.

Mazur, K. M. 1992. Fall Food of the Eastern Screech-Owl in Manitoba. Blue Jay 50: 33-35.

Millsap, B. A., and **C. Bear.** 2000. Density and Reproduction of Burrowing Owls along an Urban Development Gradient. Journal of Wildlife Management 64: 33-41.

Nilon, C. H., and **L. W. VanDruff.** 1987. Analysis of small mammal community data and applications to management of urban greenspaces. Pages 53-59 *in* Integrating Man and Nature in the Metropolitan Environment. *Edited by* L. W. Adams and D. L. Leedy. National Institute Urban Wildlife, Columbia, Maryland, U.S.A.

Plumpton, D. L., and **R. S. Lutz.** 1993. Prey selection and food habits of Burrowing Owls in Colorado. Great Basin Naturalist 53: 299-304.

Racey, G. D., and **D. L. Euler.** 1982. Small mammal and habitat response to shoreline cottage development in central Ontario. Canadian Journal of Zoology 60: 865-880.

Remes, V. 2000. How can maladaptive habitat choice generate source-sink population dynamics? Oikos 91: 579-582.

Reynolds, J. W. 2000. A contribution to our knowledge of the earthworm fauna of Manitoba, Canada (Oligochaeta, Lumbricidae), Megadrilogica 8: 9-12.

Richards, N. L., P. Mineau, D. M. Bird, P. Wery, J. Larivée, and **J. Duffe.** 2006. First observations of an Eastern Screech-Owl, *Megascops asio*, population in an apple-

producing region of southern Quebec. Canadian Field-Naturalist 120: 289-293.

Ritchison G., and **P. M. Cavanagh.** 1992. Prey use by Eastern Screech Owls: seasonal variation in central Kentucky and a review of previous studies. Journal of Raptor Research. 26: 66-73.

Sibley, D. A. 2000. National Audubon Society – The Sibley Guide to Birds. Knopf, New York, U.S.A.

Stewart, P. A. 1969. Prey in two screech owl nests. Auk 86: 141.

Taylor, P., and **R. Koes.** 1995. Rare and marginal winter passerine birds in Manitoba. Blue Jay 53: 148-158.

Turner, L. J., and **R. W. Dimmick.** 1981. Seasonal prey capture by the screech owl in Tennessee. Journal of Tennessee Academy of Science 56: 56-59.

U.S. National Fish and Wildlife Forensics Laboratory. Feather Atlas Website. Retrieved September 2004 – December 2008 from http://www.lab.fws.gov/featheratlas.

VanCamp, L. F., and **C. J. Henny.** 1975. The Screech Owl: Its Life History and Population Ecology in Northern Ohio. North American Fauna: 71. Unites States Department of the Interior Fish and Wildlife Service.

VanDruff, L. W., and **R. N. Rowse.** 1986. Habitat association of mammals in Syracuse, New York. Urban Ecology 9: 413-434.

Wageningen University Experimental Zoology Group. Skull site. Retrieved September 2004 – December 2008 from: http://www.skullsite.com/index.htm.

Wilson, K. A. 1938. Owl studies at Ann Arbor, Michigan. Auk 55: 187-197.

Wolf, B. O., and **C. M. del Rio.** 2000. Use of saguaro fruit by white-winged doves: isotopic evidence of a tight ecological association. Oecologia 124: 536-543.

Yom-Tov, Y., and **D. Wool.** 1997. Do the contents of Barn Owl pellets accurately represent the proportion of prey species in the field? Condor 99: 972-976.

York, M. M., D. K. Rosenberg, and **K. K. Sturm.** 2002. Diet and food-niche breadth of Burrowing Owls (*Athene cunicularia*) in the Imperial Valley, California. Western North American Naturalist 62: 280-287.

Received 31 October 2009
Accepted 23 September 2010

APPENDIX: Prey by species of Eastern Screech-Owl from March 2004 – February 2008.

Prey Item	Total Captured	**Biomass**
BIRDS	**n = 344**	**9601g**
Passerines	*282 (82%)*	*5984g (62%)*
Non-passerines	*11 (3%)*	*1444g (15%)*
Unidentified bird	*51 (15%)*	*2173g (23%)*
Unidentified small passerine	90 (26%)	1782g (19%)
House Sparrow	43 (13%)	1204g (13%)
Unidentified sparrow or finch	33 (10%)	662g (7%)
Black-capped Chickadee	30 (9%)	330g (3%)
Unidentified warbler	19 (6%)	190g (2%)
Cedar Waxwing	9 (3%)	288g (3%)
Yellow-rumped Warbler	9 (3%)	111g (1%)
American Redstart	7 (2%)	58g (1%)
Yellow Warbler	6 (2%)	57g (1%)
House Finch and *Carpodacus* sp	6 (2%)	128g (1%)
White-breasted Nuthatch	4 (1%)	84g (1%)
Rock Pigeon	4 (1%)	1080g (11%)
American Robin	3 (1%)	231g (2%)
Catharus sp	3 (1%)	93g (1%)
Hairy Woodpecker	3 (1%)	198g (2%)
Downy Woodpecker	3 (1%)	81g (1%)
Tennessee Warbler	3 (1%)	30g (0.3%)
Northern Shrike	2 (1%)	130g (1%)
Blue Jay	2 (1%)	170g (2%)
American Goldfinch	2 (1%)	26g (0.3%)
European Starling	2 (1%)	164g (2%)
House Wren	2 (1%)	22g (0.2%)
Dark-eyed Junco	2 (1%)	38g (0.4%)
Virginia Rail	1 (0.3%)	85g (1%)
White-throated Sparrow	1 (0.3%)	26g (0.3%)
Baltimore Oriole	1 (0.3%)	33g (0.3%)
Pine Grosbeak	1 (0.3%)	56g (1%)
Rose-breasted Grosbeak	1 (0.3%)	45g (0.5%)
Regulus sp	1 (0.3%)	6g (0.1%)

APPENDIX: *(continued)*

Prey Item	Total Captured	Biomass
MAMMALS	**n = 429**	**17698g**
Rodent	*418 (97%)*	*17276g (98%)*
Non-rodent	*11 (3%)*	*422g (2%)*
Meadow Vole and unidentified vole	292 (68%)	14308g (81%)
House mouse	55 (13%)	1128g (6%)
Unidentified small mammal	26 (6%)	780g (4%)
Deermouse	24 (6%)	480g (3%)
Unidentified rodent	21 (5%)	580g (3%)
Little Brown Bat	6 (1%)	240g (1%)
Northern Short-tailed Shrew	4 (1%)	82g (0.5%)
Red Squirrel (young)	1 (0.2%)	100g (1%)
AMPHIBIANS AND FISH	**n = 8**	**119g**
Unidentified frog	3 (38%)	45g (38%)
Northern Leopard Frog	2 (25%)	40g (34%)
Wood Frog	2 (25%)	24g (20%)
Unidentified fish	1 (13%)	10g (8%)
Invertebrates	**n = 1542**	**3277g**
Hard (detectable in pellets)	*690 (45%)*	1425g (43%)
Soft (not detectable in pellets)	*179 (12%)*	338g (10%)
Unidentified invertebrate	*673 (44%)*	*1514g (46%)*
Beetle: Scarabidae	554 (36%)	1108g (34%)
Beetle: family unknown	76 (5%)	152g (5%)
Beetle: Carabidae	29 (2%)	58g (2%)
Beetle: Staphylinidae	3 (0.2%)	6g (0.2%)
Beetle: Coccinellidae	3 (0.2%)	3g (0.1%)
Earthworm (mostly *Lumbricus terrestris*)	79 (5%)	158g (5%)
Caterpillar sp	56 (4%)	112g (3%)
Moth (mostly Noctuidae)	36 (2%)	54g (2%)
Winged insect	12 (1%)	42g (1%)
Crayfish sp	7 (0.5%)	37g (1%)
Dragonfly sp	5 (0.3%)	15g (0.5%)
Larvae or pupae	4 (0.3%)	8g (0.2%)
Slug sp	2 (0.1%)	2g (0.1%)
Spider sp	2 (0.1%)	4g (0.1%)
Cockroach sp	1 (0.1%)	4g (0.1%)

Twenty "*Microtus* sp" are all most likely to be Meadow Voles hence combined. Beetle identifications are imperfect and the number of Scarabidae may be inflated due to other families with similar head or leg shapes. Most of the unidentified invertebrates were observed and were most likely small beetles or other very small prey. The most common Scarabidae prey are in the genus *Phyllophaga*, the most common Carabidae prey are in the genus *Calosoma*.

Over-wintering Characteristics of West-Central Wisconsin Blanding's Turtles, *Emydoidea blandingii*

RICHARD P. THIEL[1] and TIMOTHY T. WILDER[2]

[1]Wisconsin Department of Natural Resources, Sandhill Wildlife Area, 1715 Hwy X, Babcock, Wisconsin 54413 USA
[2]Department of the Army, Directorate of Public Works, IMNE-MCY-PWEN, 2171 South 8th Avenue, Fort McCoy, Wisconsin 54656-5136 USA

Thiel, Richard P. and Timothy Wilder. 2010. Over-wintering characteristics of west-central Wisconsin Blanding's Turtles, *Emydoidea blandingii*. Canadian Field-Naturalist 124(2): 134–138.

Hibernation of adult-sized Blanding's Turtles was studied at two west-central Wisconsin sites between 1991 and 2008. Turtles arrived at hibernacula from mid September to early October, spending 126 to 216 days at these sites, and generally emerged in early April yearly. Sixty percent of females and 30 percent of males hibernated in natural over man-made structures as hibernation sites. Anoxic conditions near five hibernation sites ranged from 78 to 100 days. Shell temperatures of three turtles monitored over five winters remained at <1°C a mean of 2,274 hours each winter. Over the same period, four turtles' temperatures were between 0° and -1°C a mean of 302 hours. During the course of our study, hibernating west-central Wisconsin Blanding's Turtles demonstrated a remarkable degree of both cold and anoxia-tolerance similar to that observed among Painted Turtles (*Chrysemys picta*) and Snapping Turtles (*Chelydra serpentina*).

Key Words: Blanding's Turtle, *Emydoidea blandingii*, anoxia, cold tolerance, hibernation, dissolved oxygen, Wisconsin.

Blanding's Turtles (*Emydoidea blandingii*) are a northern temperate-distributed freshwater turtle species presently experiencing anthropogenic-caused, range-wide population declines (Schuler and Thiel 2008, Ernst et al.1994). Over their long life spans Blanding's Turtles experience widely varying winter weather conditions of unpredictable lengths in which they must hibernate. Wisconsin winters includes periodic freeze-thaw cycles, deep cold, snow and ice accumulations that frequently penetrate well into bottom sediments and deny turtles hibernating in shallow marsh basins access to atmospheric oxygen. The extreme variables of winter weather from year-to-year are a challenge to turtles. In Wisconsin the number of turtle species decreases from eleven in the south to only four in the north – a decrease of more than 60 percent in species diversity within a 450 km north-south gradient (Vogt 1981).

When we began our monitoring activities on Blanding's Turtles in the early 1990's, little information was available on physiological mechanisms of hibernating northern temperate turtle species (Jackson 1979). Two physiological over-wintering strategies are presently recognized among northern freshwater turtles: those that are anoxia-intolerant (death < 50 days), and those that are anoxia-tolerant (death > 100 days) (Ultsch 2006, Ultsch and Reese 2008). Even within a species, tolerance among individuals varies by locality. Reese et al. (2004) demonstrated that Painted Turtles displayed varying tolerance to anoxia depending on whether individuals were from the northern or southern edge of their continental range.

Ultsch (2006) believed that Blanding's Turtles are anoxia-tolerant because they share similar over-wintering habitats with Snapping and Painted Turtles. The species' winter metabolic rate (oxygen demand) is reported to be between the values of Painted and Snapping Turtles (Graham and Butler 1993). Kofron and Schreiber (1985) reported two adult Blanding's Turtles remained somewhat active in winter in their Missouri study site near the southern portion of the species' range, moving by as much as 13 m at water temperatures of 6.2-7.5°C at depths of 9-21cm in mud in a Missouri marsh. Once water temperature dropped to 2-3°C, weekly locations declined to 1-2 m. This contrasts with the relative lack of movements observed among Blanding's Turtles in mid-winter from Nova Scotia and Ontario (Newton and Herman 2009, Edge et al. 2009). These observations from the southern, eastern and northern edges of the Blanding's Turtle's continental range show that the species exhibits tolerance to cold water temperatures during hibernation, eliminating movements at very cold temperatures.

We report on various aspects of hibernation observed among Blanding's Turtles studied in west-central Wisconsin over a 2-decade period. We were interested in assessing the ratio of man-made to natural hibernation sites in our human-modified landscapes. We also document the duration, in days, Blanding's Turtles spent at hibernation sites by comparing late autumn and early spring sightings and captures of Blanding's Turtles to radio telemetry data on arrival and departure dates from hibernation sites. We compared this to data from several turtles outfitted with thermal data loggers to refine our estimates of the duration of hibernation among Blanding's Turtles in central Wisconsin. We report on Blanding's Turtle tolerance to near-freezing conditions, and dissolved oxygen levels at a small number of hibernation sites to assess Blanding's Turtle tolerance to anoxic conditions.

We hypothesized that Blanding's Turtles would show avoidance of man-made sites to hibernate in; that duration spent at hibernation sites would exceed 120 days; and that Blanding's Turtles would display tolerance similar to that of Painted Turtles and Snapping Turtles to both near-freezing and anoxic conditions.

Methods

Winter weather: Long-term average monthly temperatures at Wisconsin Rapids, located 50 km east of SWA were: September, 15°C; October, 8.3°C; November, 0°C; December, -7°C; January -10°C; February, -7°C; March -0.5°C; and April 7°C (NOAA*). Ice and snow covered Blanding's Turtle hibernation sites generally from mid-December to late March for the duration of the study at SWA (Thiel, unpublished notes).

Sandhill Wildlife Area (SWA): is a 3,884 hectare facility, located in west-central Wood County, Wisconsin (Latitude 44°, 17'; Longitude 90°, 10') containing approximately 50 percent upland forests of *Quercus* spp., *Populus* spp. and scattered pine *Pinus* spp. Wetlands consist of a variety of man-made flowages, ranging from 35 to 1,200 ha. Predominant vegetation consists of *Sphagnum* spp., sedges, rushes, bluejoint grass (*Calamagrotis canadensis*), and *Salix* spp. and *Spirea* spp. on drier sites. Water levels are regulated by bulkheads on inter-connecting ditches, and recharge is primarily through precipitation.

Blanding's Turtles were captured and marked between 1991 and 2008 as staff was conducting other field work. In 1997, 1998, and 2002 Blanding's Turtles were also captured on SWA using hoop nets baited with dead fish. Between 2001 and 2008 evening nesting surveys were run on SWA to encounter adult female Blanding's Turtles. Between one and four turtles were radioed and monitored each year from those that were captured annually.

Fort McCoy Military Installation (FMMI): is a 22,184 hectare military installation, located in north-central Monroe County, Wisconsin, Latitude 44°, 0'; Longitude 90°, 40', containing approximately 93 percent upland forests of *Quecus* spp., *Pinus* spp., *Acer rubrum*, and *Populus* spp. Wetlands consist of 11 man-made ponds and flowages ranging in size from 1.2 ha to 100.0 ha. Additionally, there are 114.6 km of streams on the installation. Predominant vegetation consists of *Sphagnum* spp., sedges, tag alder (*Alnus incana*), and poison sumac (*Rhus vernix*). In all but one flowage, water levels are regulated through precipitation and ground water recharge.

Between 1999 and 2008 surveys were conducted on FMMI by walking marsh and stream edges searching for and capturing Blanding's Turtles that had recently emerged from hibernation. From 2001 to 2006, Blanding's Turtles were also captured on FMMI using hoop nets and wire mesh turtle traps baited with dead fish.

Captured turtles were weighed to the nearest 1.0 g using a triple beam-balance scale at SWA and a digital scale at FMMI. Each was sexed, and series of coded marginal scutes were filed to individually mark each (Cagle 1939). Blanding's Turtles were considered adult with carapace lengths in excess of 191 mm (Thiel, unpublished notes).

Radio transmitters (Advanced Telemetry Systems, Model R1930, Isanti, MN) were glued to the left or right anterior portion of the carapace of 2–5 Blanding's Turtles annually beginning in 1993 at SWA and 2000 at FMMI. Turtles were located at one or two week intervals throughout the summer foraging season and into autumn until movements ceased. Each winter radioed turtles were located twice monthly at SWA; once or twice during winter at FMMI after movements ceased. Therefore our comments on winter movement are restricted to SWA. In mid to late March radioed turtles' hibernation sites were visited at least twice weekly to determine date of first emergence. With one sole exception, turtles at these sites were not disturbed.

We defined over-wintering as the period of time, in days, that radioed turtles' movements ceased (< 2m).

Hibernation sites were categorized as man-made structures, including dikes, drainage ditches, hand dug ditches and borrow pits. Natural sites included Beaver (*Castor canadensis*) channels, open water including those in man-made flowages, emergent vegetation and riverine environments. We did not conduct micro-habitat evaluations of hibernation sites. Fidelity to over-wintering sites was assessed for individual radioed Blanding's Turtles monitored greater than one winter period.

We calculated the range, in days, between latest autumn and earliest spring visual observations of Blanding's Turtles, and the range, in days, between arrival and departure of radioed turtles from their hibernation sites. A date was assigned mid-way between two succeeding locations for radioed turtles if the exact arrival / emergence date was unknown. Events spanning greater than 20 days (± 10 days) were censored. Median autumn arrival and spring departure dates were determined from pooled radio telemetry data because we had insufficient sample sizes for individual winters. Hibernation, in days, was calculated by summing the days between the median dates of arrival and emergence for all radioed turtles.

A small number of radioed turtles were outfitted with a HOBO® TidbiT®[1] thermal recorder glued to the carapace adjacent to the transmitter. We interpreted a spike of greater than 2.5°C within a single two-hour interval as basking behavior, and calculated the duration of hibernation, in days, between the latest logged autumn and earliest spring basking event.

[1] Onset Computer Corporation, 470 MacArthur Blvd., Bourne, Massachusetts 02532 USA

Thermal regimes of radioed hibernating turtles were assessed in winters 1997-98, 1998-99, 1999-2000 and 2000-01. These were considered accurate to within 0.5°C. TidbiTs® were calibrated to record temperature at one hour intervals in winter 1997-98. Thereafter they were calibrated at two hour intervals. TidbiT® loggers retrieved in spring were down-loaded to an excel spreadsheet. We determined the number of individual events and interval lengths (hours per event) turtle exterior shell temperatures reached or fell beneath 1°C and also between 0 and -1°C.

Dissolved oxygen (DO) (mg/L) was obtained at irregular intervals by drilling a hole through the ice and extracting a water sample within one meter of five radioed hibernating SWA turtles (representing 6 turtle-winters) in winters 1993-94 (n=1 turtle), 1994-95 (n=3 turtles) and 1995-96 (n=2 turtles). Accuracy in our analysis was 0.5mg/L. We used Newton and Herman's (2009) definition of anoxia as DO levels of 0 and calculated the minimum number of days radioed turtles were at hibernation sites with DOs recorded as 0.

Statistica ® was used to perform χ^2 analyses of differences between use of man-made vs. natural environments between males and females; re-use of man-made vs. natural environments between males and females; re-use of sites; and re-use of sites by all females sampled vs. females with a minimum of three consecutive winters of hibernation site data. T-tests were used to analyze the range, in days, that SWA vs, FMMI turtles remained at sites; the range, in days, that females remained at sites; and to determine whether the greater length of time SWA females spent at hibernation sites was truly different than females at FMMI. Significance was accepted at $P < 0.05$.

Results

Ratios of Man-Made vs. Natural Sites

We tallied 44 hibernation sites used by 19 female Blanding's Turtles (14 FMMI; 5 SWA) monitored a mean of 2.1 winters (range 1 to 5 winters), and 27 hibernation sites used by 13 male Blanding's Turtles (3 FMMI; 10 SWA), monitored a mean of 2.1 winters (range 1 to 7 winters). Female selection of natural overwintering sites (60 percent, 26 vs. 18) differed significantly from males (30 percent, 8 vs. 19)(χ^2; df = 1; $P = 0.03$). Thirty-two percent of females and 60 percent of males re-used former sites (but not necessarily in consecutive winters). This was not significant (χ^2; df = 1; $P = 0.23$). Frequency of re-use of natural sites did not differ between genders (20 percent for females vs. 50 percent for males; χ^2; df = 1; $P = 0.95$).

Arrival and Emergence Dates

Arrival at hibernation sites from autumn observations and capture samples ranged from 17 September to 10 November. At SWA 10 radioed males and 5 radioed females (30 combined events) arrived at hibernation sites from 1 September to 18 November with a calculated median entry date of 24 September. Arrival dates for 2 radioed FMMI males and 12 radioed females (16 events) was 1 September to 6 November with a calculated mean arrival date of 19 October.

Emergence dates from spring observations and capture samples ranged from 26 March to 9 May. Emergence dates of 9 SWA radioed males and 4 radioed females (27 combined events) ranged from 26 March to 20 April with a median date of 9 April. Emergence dates for 2 FMMI radioed males and 8 radioed females ranged from 28 March to 20 April, with a median date of 6 April.

Duration at Hibernation Sites

The interval between median arrival and departure dates among late autumn (n=21) and early spring (n=65) observations and captures of Blanding's Turtles was 198 days. The interval between median arrival (n=25) and emergence dates (n=16) among radioed SWA turtles was 197 days, in contrast to a span of 166 days between median arrival and emergence dates among radioed FMMI turtles.

Entry and emergence dates within a single winter were known for 10 individual radioed male SWA turtles, and these averaged 181 days (range:147 – 211 days) in contrast to two radioed FMMI males who averaged 164 days (range:153-174 days). This difference was not significant (t-test; df = 2; $P = 0.15$). Five radioed SWA females averaged 185 days (range:163 – 216 days) and 7 radioed FMMI females averaged 171 days (range:153–195 days). This difference approached significance (t-test; df = 9; $P = 0.058$). Combining males and females and comparing between the two study sites, duration at hibernation sites was significantly greater at SWA (t-test; df = 29; $P = 0.02$). Duration of hibernation from one female and two males wearing TidbiT® thermal loggers (totaling 5 winters) ranged from 126 to 187 days, and averaged 165 days.

Radioed SWA females remained inactive at hibernation sites an average of 15.75 days longer (range, 6-29 days) than males in the same winter (n = 5 winters). Similarly a single radioed FMMI female remained inactive 24.5 days longer than two males over the same winter, but the difference between the SWA and FMMI values was not significant (t-test; df = 2; $P = 0,27$). When we combined the two study sites, the duration of females was significantly greater than males (t-test; df = 10; $P = 0.048$).

Anoxia

Anoxic conditions were reached between 5 December and 10 January (median = 23 December) in the vicinity of hibernation sites of four turtles, and re-oxygenation occurred between 13 March and 3 April (median = 24 March) (Table 1). Using the latest autumn and earliest spring dates and comparing this to median dates for all recorded events, the length of time Blanding's Turtles endured anoxic conditions ranged from 78 to 100 days and averaged 87 days.

Cold Tolerance

Shell temperatures were monitored on three Blanding's Turtles a total of five winters. In winter 1997-98, when TidbiT® loggers were calibrated at one hour intervals, shell temperatures were recorded an average of 166 days per winter (n=12,156 hourly events). Thereafter loggers were calibrated at two hour intervals, recording an average of 204 days per winter (n=7, 329 2-hour events).

Loggers placed on three Blanding's Turtles accumulated 19 485 h of temperature data (five Blanding's Turtle winters) and recorded 109 events below 1°C. Each turtle averaged 22 events (range 13 to 31) and an average of 2,274 hours (58 percent of 19,485 h; range 1604 to 3202 h) below 1°C per winter. Individual events lasted an average of 98 h (range 1 to 1848 h).

Temperatures between 0 and -1°C were recorded in 26 events (average = 26; range 15 – 80) averaging 302 hours per winter per turtle (1.5 percent of 19 485 h.; range 60 to 756 h. Individual turtles averaged 6.5 events (range 0 – 80) lasting an average of 11.6 h (range 1 to 74 h).

Discussion

Ratios of Man-Made vs. Natural Sites

Unlike the study sites of both Edge et al. (2009) and Newton and Herman (2009) much of the Blanding's Turtle's continental range today occurs in human-dominated landscapes. Blanding's Turtle habitat in our study sites has been manipulated by humans. The species readily used man-made or man-modified structures to hibernate in, although males were more likely than females to use such areas.

Approximately 50 percent of the Algonquin Provincial Park, Ontario turtles returned to the same hibernation site in the following winter (Edge et al. 2009). In Central Wisconsin, 33 percent of radioed turtles returned to the same site in the following winter. However, we had the opportunity to observe some turtles for more than two consecutive winters and re-use of former sites was variable. Over a five-winter period FMMI female 4BDFM99 used a road-side borrow pit in two consecutive winters but different sites in subsequent winters. Five different sites were used by SWA female 75 over a seven-winter period; including two separate sites used two consecutive years each. SWA male 188 used the same borrow pit over five consecutive winters. The tendency to re-use previous hibernation sites is likely reduced, considering that SWA turtles had greatly altered home ranges from year-to-year (Schuler and Thiel 2008).

Duration of Inactivity at Over-Wintering Sites

Blanding's Turtles in west-central Wisconsin arrive at hibernation sites between mid September and late October. Our arrival dates agree with observations of Newton and Herman (2009) from Nova Scotia (September to mid-November), and Edge et al. (2009) from Ontario (October). Newton and Herman (2009) reported their Blanding's Turtles moved locally 5 to 15 m within the mid-winter period. Movements were positively correlated with warmer water temperature. Edge et al. (2009) noted that turtles moved little in winter following ice formation, remaining beneath at least 10 cm of free water. By contrast, SWA turtles seldom moved after arriving at their hibernation sites in September or October.

Our emergence dates ranged from 28 March to 20 April. This coincides with observations of emergence from Nova Scotia (Newton and Herman 2009) of late March to mid April, and between 11 and 14 April from Ontario (Edge et al. 2009). An exceptionally late case occurred on 9 May when a basking turtle was encountered in a SWA marsh. Inspecting the site we discovered a matrix of frozen and thawing sediment extending down 20 cm overlaying a thawed matrix 25 cm thick that lay on top of a completely frozen layer of sediment of unknown depth. We felt this turtle had just managed to extricate itself from this partially thawed substrate.

Blanding's Turtles in our study areas spent from 126 to 216 days at hibernation sites each winter. Our TidbiT® thermal data indicated that Blanding's Turtles spent an average 164 days inactive at hibernation sites. This is nearly a month longer than the 101 to 136 days reported for the species in Ontario (Edge et al. 2009). Males in our study area tended to arrive later than females each autumn, and their duration of hibernation was shorter. The variation in duration exhibited by our turtles reflect the Blanding's Turtle's capacity to endure highly variable winter lengths.

Anoxia and Cold Tolerance

Newton and Herman (2009) and Edge et al. (2009) demonstrated that Blanding's Turtles are hypoxic-tolerant, inhabiting sites with DOs ranging from 2.8 to 11.3 mg/L in Nova Scotia and 2.6 to 3.4 mg/L in Ontario, respectively. At the latter site, turtles were denied access to atmospheric oxygen for periods ranging from 101 to 136 days because of ice. Anoxia conditions in the vicinity of SWA Blanding's Turtle hibernation sites ranged from 78 to 100 days and averaged 87 days. This corresponds with the average of 95 days spent by five SWA turtles at temperatures of less than 1°C.

In SWA ice was present from early December to late March each year (Thiel, unpublished notes). At several hibernation sites with autumn surface water depths of 10-25 cm no liquid water existed extending 10 cm into the underlying sediment column by January so DOs could not be measured. Blanding's Turtles could not move in response to extremely cold or anoxia conditions. This contrasts to winter movements of Blanding's Turtles in Missouri and Nova Scotia (Kofron and Schreiber 1985; Newton and Herman 2009). These were not isolated cases. SWA female 39 hibernated in a one hundred year old, sediment filled, hand-dug ditch in the relatively snow-free winter of 1994-

TABLE 1. Length, in days, of anoxic conditions at Blanding's Turtle hibernation sites.

		Anoxia reached…			Re-oxygenated...			Days between Medians
Turtle	Year	between		median	between		Median	
36M	1993-94				16 March	24 March	20 March	
16M	1994-95	3 January	10 January	07 January	16 March	03 April	25 March	78
39F	1994-95	5 December	21 December	13 December	13 March	02 April	23 March	100
58M	1995-96	22 December	10 January	01 January				
23F	1995-96	22 December	10 January	01 January	20 March	26 March	23 March	82
							Average =	87

95. Between at least 3 January and 13 March solid ice extended into the sediment and no liquid water remained at the hibernation site. On 2 April the ice was gone and the turtle was located alive. She survived hibernating in a micro-environment, incapable of escaping, a minimum of 77 days near freezing, and 100 days in an anoxic condition (Table 1).

In 66 turtle-winters of data accumulated in this study, only one death (1.5 percent) was attributed to complications associated with hibernation. Although not autopsied, we speculated this FMMI Blanding's Turtle suffered tissue damage caused by freezing. At ice-up maximum water depth was approximately 60 cm at her hibernation site. A lack of snowfall during the winter allowed frost to penetrate deeper than normal into the soil. When located on April 28, she was found dead in 30 cm water within a few meters of her hibernation site. She had evidently aroused from hibernation but had expired shortly thereafter.

Our data corroborate the findings of both Newton and Herman (2009) and Edge et al. (2009) that Blanding's Turtles are both freeze and anoxia-tolerant similar to Painted and Snapping turtles (Ultsch 2006; Ultsch and Reese 2008). Blanding's Turtles are well suited to endure the widely variable winter lengths experienced at these latitudes, clearly important for a species occupying the northern fringe of Testudine distribution within North America.

Acknowledgments

We thank Matt Schuler for performing the statistical analyses and numerous high school students, staff and volunteers for their efforts in monitoring Blanding's Turtles at both SWA and FMMI.

Documents Cited (marked * in text)

National Oceanic and Atmospheric Administration. http://www.crh.noaa.gov/images/grb/data/climate/dnorms/DR WISCONSINRAPIDS.xls. Accessed 14 December 2009.

Literature Cited

Cagle, F. R. 1939. A system for marking turtles for future identification. Copeia 1939: 170-173.

Edge, C. B., B. D. Steinberg, R. J. Brooks, and J. D. Litzgus. 2009. Temperature and site selection by Blanding's turtles (*Emydoidea blandingii*) during hibernation near the species' northern range limit. Canadian Journal of Zoology 87: 825-834.

Ernst, C. H., J. E. Lovitch, and **R. W. Barbour.** 1994. Turtles of the United States and Canada. Smithsonian Institution Press. Washington, D.C.

Graham, T. E., and **B. O. Butler.** 1993. Metabolic rates of wintering Blanding's turtles, *Emydoidea blandingii*. Comparative Biochemistry and Physiology 106A: 663-665.

Jackson, D. C. 1979. Respiration. Pages 165-191 *in* Turtles: perspectives and research. *Edited by* John Wiley and Sons, New York.

Kofron, C. P., and **A. A. Schreiber.** 1985. Ecology of two endangered aquatic turtles in Missouri: *Kinosternon flavescens* and *Emydoidea blandingii*. Journal of Herpetology 19: 27-40.

Newton, E. J., and **T. B. Herman.** 2009. Habitat, movements, and behavious of overwintering Blanding's turtles (*Emydoidea blandingii*) in Nova Scotia. Canadian Journal of Zoology 87: 299-309.

Reese, S. A., E. R. Stewart, C. E. Crocker, D. L. Jackson, and **G. R. Ultsch.** 2004. Geographic variation of the physiographic response to overwintering in the painted turtle (*Chrysemys picta*). Physiological and Biochemical Zoology 77: 619-630.

Schuler, Matthew, and **Richard P. Thiel.** 2008. Annual vs. multiple – year home range sizes of individual Blanding's turtles, *Emydoidea blandingii*, in central Wisconsin. Canadian Field-Naturalist 122: 61-64.

Ultsch, Gordon R. 2006. The ecology of overwintering among turtles: where turtles overwinter and its consequences. Biological Reviews 81: 339-367.

Ultsch, Gordon R., and **Scott A. Reese.** 2008. Ecology and physiology of overwintering. Pages 91-99 *in* Biology of the Snapping Turtle (*Chelydra serpentina*). *Edited by* A. C. Steyermark, M. S. Finkler and R. J. Brooks. The Johns Hopkins University Press. Baltimore, Maryland.

Vogt, R. C. 1981. Natural history of amphibians and reptiles of Wisconsin. The Milwaukee Public Museum, Milwaukee, Wisconsin. 205 pages.

Received 15 December 2009
Accepted 23 July 2010

Wolverine, *Gulo gulo*, Home Range Size and Denning Habitat in Lowland Boreal Forest in Ontario

F. NEIL DAWSON[1], AUDREY J. MAGOUN[2], JEFF BOWMAN[3], and JUSTINA C. RAY[4]

[1]Ontario Ministry of Natural Resources, RR#1, 25th Side Road, Thunder Bay, Ontario P7C 4T9 Canada; e-mail: neil.dawson@ontario.ca
[2]Wildlife Research and Management (WRAM), 3680 Non Road, Fairbanks, Alaska 99709 USA
[3]Ontario Ministry of Natural Resources, 2140 East Bank Drive, Peterborough, Ontario K9J 7B8 Canada
[4]Wildlife Conservation Society Canada, 720 Spadina Avenue, #600, Toronto, Ontario M5S 2T9 Canada

Dawson, F. Neil, Audrey J. Magoun, Jeff Bowman, and Justina C. Ray. 2010. Wolverine, *Gulo gulo*, home range size and denning habitat in lowland boreal forest in Ontario. Canadian Field-Naturalist 124(2): 139–144.

We conducted the first radio-telemetry study of Wolverines in northwestern Ontario during the winter of 2003-2004 to determine whether home ranges and movements of Wolverines in lowland boreal forest were typical of this species in other ecosystems and to describe reproductive den sites in this habitat type. Seven Wolverines (3 M, 4 F) were radio-tagged and monitored for 31 to 269 (Mean ± SE = 153 ± 35) days using a combination of remotely monitored Argos satellite and conventional aerial telemetry. Male and female 95% minimum convex polygon (MCP) home ranges (±SE) during December to October were 2,563 (796) km^2 and 428 (118) km^2, respectively, for combined VHF and Argos locations. A lactating female had a 95% MCP home range of 262 km^2. The den site for this female included large boulders and downed trees, similar to dens described for this species in montane ecosystems. Boulder complexes and downed trees may be critical features of wolverine dens in lowland boreal forests. Mean road densities (± SE) within 95% MCP and 50% MCP home ranges were 0.43 (0.13) and 0.33 (0.23) km/km^2, respectively, and our results suggest that road densities may affect selection of home ranges by Wolverines. The Wolverine population was a resident, reproductive population.

Key Words: Wolverine, *Gulo gulo*, home range, road density, den, Ontario.

Developing strategies for the conservation of Wolverine (*Gulo gulo*) populations in light of increasing natural resource extraction in remote regions of lowland boreal forest environments is constrained by a lack of basic ecological data in this habitat type. For example, there have been no radio-telemetry studies of this elusive species in Canada east of the Yukon (Banci 1987) and British Columbia (Krebs et al. 2007) with the exception of one study in the central Arctic north of Yellowknife, Northwest Territories (Mulders 2000*). To date, all radio-telemetry studies of Wolverine have taken place in habitats characterized by mountains or tundra (Hornocker and Hash 1981; Gardner 1985; Magoun 1985; Whitman et al. 1986; Banci 1987; Copeland 1996; Mulders 2000*; Krebs et al. 2007; Persson et al. 2009). Such dens typically consist of extensive snow tunnels in drifted snow or under boulders, avalanche debris, or windblown trees covered by snow (Magoun and Copeland 1998), which may not occur in lowland boreal forests.

Research findings from montane and tundra habitats cannot necessarily be applied in Ontario or other lowland boreal forest areas of central Canada. Additionally, the relatively low harvest returns in central Canada compared to western North America may be indicative of lower Wolverine densities in central Canada (Slough 2007), suggesting that lowland boreal forest may constitute marginal habitat for Wolverines.

Our objectives were to determine Wolverine home ranges in the lowland boreal forests of central Canada; whether the study population was a resident, reproductive population; and document characteristics of any den sites encountered. The location of the study area at the northern limit of road development in the boreal forest also provided an opportunity to evaluate how anthropogenic activity (road density) influenced home range placement. We report results of the first radio-telemetry study of Wolverine home ranges in lowland boreal forests in central North America and describe a reproductive den site found in this habitat type.

Methods

Our study took place during the winter of 2003-2004 in a 6 600-km^2 area near Red Lake, Ontario (51°N, 93°W) (Figure 1). Forests were comprised primarily of Black Spruce (*Picea mariana*) and Jack Pine (*Pinus banksiana*); Trembling Aspen (*Populus tremuloides*) and White Birch (*Betula papyrifera*) were the major deciduous species present. The area has a gently rolling topography with elevations ranging from 250 to 500 m above sea level, with numerous lakes. Large forest fires (>100 km^2) occurred in most decades. The study area was being actively logged using the clearcut silvicultural system with individual cut-blocks varying in size from one to several hundred km^2. Dominant ungulates in the study area were Moose (*Alces americanus*) and Caribou (*Rangifer tarandus*), with small numbers of White-tailed Deer (*Odocoileus virginianus*) occurring in the southern portion. Primary larger predators in the

area were Gray Wolf (*Canis lupus*), Black Bear (*Ursus americanus*), and Canada Lynx (*Lynx canadensis*).

We captured Wolverines in wooden live-traps (Lofroth et al. 2008) between December 13, 2003 and March 24, 2004. Twenty-five traps were set along a mix of plowed and unplowed logging roads, and baited with road-killed White-tailed Deer and Moose, or trapper-killed Beaver (*Castor canadensis*) carcasses. We checked traps daily and identified and released any non-target species captured. We immobilized captured Wolverines with tiletamine hydrogen chloride (HCl) and zolazepam HCl (Telazol®; Fort Dodge Animal Health, Fort Dodge, IA) at a dosage of 10 mg/kg (Golden et al. 2002). They were then outfitted with a Kiwi-Sat 101 Argos satellite/very high frequency (VHF) radio collar (Sirtrack Limited, Havelock North, New Zealand). We weighed and sexed each study animal, and estimated its age based on tooth wear and development of teats or testes (Magoun 1985). We marked animals in each ear with uniquely numbered and coloured ear tags, and collected tissue samples for DNA analysis. Each Wolverine was returned to the trap and monitored until it had recovered from the drug. Animal capture and handling followed Ontario Ministry of Natural Resources (OMNR) approved animal handling protocols 03-77 and 04-77.

We received Argos locations daily until the collars stopped transmitting. The Argos platform terminal transmitter (PTT) operated on one of two duty cycles: two collars had a duty cycle of 8 hrs/day each day for a predicted lifespan of 120 days and four collars had a duty cycle of 8 hr/day for the first 30 days, followed thereafter by 8 hr every second day for a predicted lifespan of 310 days. We used only Argos location class (LC) 3, 2, and 1 locations in our analysis due to concerns regarding the inherent error (≥1500 m) in the other location classes (Keating et al. 1991).

We used a PA-18 Supercub fixed-wing aircraft to locate collared wolverines from the air, one to three times per day (up to five times for a lactating female) between 25 February and 8 April 2004, weather permitting. We circled the signal location at <100 m AGL until we could determine the location (+/- 100m) of the Wolverine, document the habitat type it occupied and, whenever possible, observe the animal from the aircraft and note its behaviour.

We used the Animal Movement Extension to ArcView 3.2 (Hooge and Eichenlaub 2000*) to delineate 100%, 95%, and 50% minimum convex polygon (MCP) for each collared Wolverine. Harris et al. (1990) have suggested that MCP is the only technique "strictly comparable between studies". We chose 100 and 95% MCPs as the majority of previous Wolverine studies have reported home ranges using one or both of these metrics. To represent core areas of use we delineated 50% MCPs. MCPs were calculated for VHF locations only (HR) for the six wolverines having ≥14 locations during the 44-day VHF radio-tracking period. We also compared Argos locations (LC = 3, 2, 1) collected during this 44-day period to the VHF-derived home ranges to determine the degree of overlap between the two. VHF locations were insufficient to calculate home ranges for all study animals, whereas Argos locations were more numerous and covered an extended period of animal monitoring. Consequently, to compare home range size and location for all collared wolverines we used a combination of VHF and Argos location data to delineate home ranges (HR_A) based on 100, 95 and 50% MCPs. Although concern has been expressed about autocorrelated data resulting in negatively biased estimates of home range size (Swihart and Slade 1985), we chose to include all locations for three main reasons. First, the movement rate of Wolverines (8-10 kph [Magoun 1985]) allowed the animals to cross their home range, often many times, during our sampling interval (31–269 days) so that the influence of sampling interval bias was likely negligible. Second, we were interested only in home range size and not quantitative estimates of habitat selection which may be influenced by autocorrelation (Swihart and Slade 1997; Otis and White 1999). Finally, we were concerned that we might lose important biological information if we dropped locations (De Solla et al. 1999).

A bootstrap analysis (100 replications) was conducted using the Animal Movement Extension to ArcView 3.2 (Hooge and Eichenlaub 2000*) to determine the asymptote of the number of locations required for home range calculations. Rather than using a visual estimate, we considered the asymptote to have been reached at the point at which all subsequent home range simulations were within 10% of the final bootstrap HR and HR_A simulation for that study animal. The asymptote for 95% MCPs was reached at a mean (±SE) value of 23.4 (±1.7) (range = 18–27) locations for HR calculations and 38.5 (±5.3) (range = 27-63) locations for HR_A calculations. Study animals F02 (HR_A) and M02 (HR) had too few locations to reach an asymptote and their home ranges are reported but not included in mean home range calculations.

We calculated road densities using a GIS for the 100, 95 and 50% HR_A MCPs of each Wolverine. We used the road data available in the provincial roads layer and Forest Resource Inventory (FRI) 1:20 000 digital maps which included primary though tertiary logging roads (OMNR, unpublished data).

We radio-tracked one lactating female up to 5 times per day during March and April 2004 to locate her reproductive den site (Magoun 1985, Magoun and Copeland 1998). We visited the den site on the ground in June 2004. During our radio-tracking flights, we circled this female repeatedly in an attempt to observe any kits that might be with her.

Results

We captured and collared seven Wolverines (four females, three males) during 1088 trap-nights (TN).

TABLE 1. Home range size (HR) based on minimum convex polygons (MCP) derived from all VHF radio telemetry locations for the period 25 February – 8 April 2004 for radio-collared Wolverines (*Gulo gulo*) in northwestern Ontario, Canada.

Animal	Estimated Age (yrs)	Number of Days Located	N	100% MCP	95% MCP	50% MCP
F01	1	30	33	316	235	41
F02[1]	1	0	0	-	-	-
F03	1	24	27	495	453	38
F04	3+	14	29	348	332	3
Mean [SE]				386		
[55]	340					
[63]	27					
[12]						
M01	2	29	39	1898	1434	247
M02	1	13	15	2509	2509[2]	182
M03	3 -4	29	40	1685	1308	209
Mean [SE]				1791 [106]	1371 [63]	228 [19]

[1] F02 was killed prior to the VHF monitoring period.
[2] Due to the low number of locations for this animal analysis results for 95 MCP was the same as for 100 MCP and all results for M02 are not included in the mean HR calculations

TABLE 2. Approximation of home range size (HR_A) based on minimum convex polygons (MCP) derived from a combination of Argos satellite/VHF derived locations for Wolverines (*Gulo gulo*) in during December 2003 to October 2004 in northwestern Ontario, Canada.

Animal	Period	Days Monitored	N	HR_A (km^2) 100% MCP	95% MCP	50% MCP	Road Density (km/km^2) 100% MCP	95% MCP	MCP 50%
F01	Dec. 14 – Apr. 19	128	44	431	365	141	0.489	0.551	0.433
F02[1]	Dec. 25 – Jan. 25	31	15	301	301[2]	28	1.148	1.148	1.683
F03	Feb. 7 – Oct. 14	251	68	750	656	171	0.119	0.135	0.089
F04	Mar. 23 – Jun 16	85	86	551	262	10	0.315	0.373	0.000
Mean (SE)				577 (93)	428 (118)	107 (49)	0.518 (0.223)	0.552 (0.216)	0.551 (0.389)
M01	Jan. 15 – Oct. 9	269	50	2506	2117	196	0.147	0.174	0.018
M02	Feb. 24 – May 20	87	45	4340	4109	337	0.454	0.441	0.008
M03	Feb. 28 – Oct. 3	219	61	1783	1463	317	0.363	0.201	0.100
Mean (SE)				2876 (761)	2563 (796)	283 (44)	0.321 (0.091)	0.272 (0.085)	0.042 (0.029)

[1] F02 was killed prior to the VHF monitoring period, therefore all locations are Argos LC= 3, 2, 1
[2] Due to the low number of locations for this animal analysis results for 95 MCP was the same as for 100 MCP and all results for F02 are not included in the mean HR_A calculations

Our capture rate for Wolverines was 0.83 per 100 TN, including two recaptures. The mean (SE) mass for females was 9.9 (0.4) kg and for males 13.6 (0.6) kg. All but two captured individuals appeared to be yearlings or sub-adults, based on tooth wear. One female (F04) was lactating at the time of her capture on 23 March.

A total of 3369 Argos locations for all Wolverines was received in the following location classes (LC): LC3 = 2.1%; LC2 = 2.6%; LC1 = 4.9%; LCA = 11.8%; LCB = 22.5%; LC0 = 2.8% and LCZ = 53.4%. Argos LC 3, 2 and 1 fixes were available for five of the seven Wolverines during the 44-day VHF monitoring period. Study animal F02 was killed prior to the monitoring period, and no fixes in these LCs were obtained from Wolverine M01 during this period. Of the 32 Argos fixes obtained from the remaining 5 Wolverines during the VHF monitoring period, 28 (87.5%) were within the VHF-derived 100% MCP for the appropriate animal. The distances of the four locations falling outside the 100% MCP were 0.6 km for study animal F03, 2.3 km for F04, and 3.5 and 8.2 km for M02.

Male home range estimates based on both VHF locations only (HR; Table 1) and a combination of VHF and Argos locations (HR_A; Table 2) were substantially

larger than estimates for females in all cases; mean values for males were about 4.5 times larger than for females (Table 1, Figure 1). The lactating female F04 had the smallest HR_A for both 95 and 50% MCP home ranges (Table 2).

We documented three, and possibly four, mortalities among the collared animals. Study animals F01 and F02 were incidentally trapped 13 months and 31 days after collaring, respectively. We detected no mortality of male Wolverines during the study; however, M02 was killed by a vehicle on 22 January 2009, 100 km E of his last known location and 18 km S of his capture site. The fate of F04 was unclear; we located her collar and some animal remains about 100 m apart 4 months after she was collared, and there were signs of both Wolf and Black Bear in the vicinity. We were unable to determine if the remains were those of F04, or if she simply shed her collar.

We compared road densities (±SE) within the 100, 95, and 50% MCP HR_A (Table 2). Road density averaged 0.43 (0.13) km/km^2 within 95% MCP HR_A and 0.33 (0.23) km/km^2 within 50% MCP HR_A. A Wilcoxon's signed-rank test demonstrated that road densities were not significantly lower within the 50% MCP HR_A ($z = -1.18$, $p = 0.237$). It is notable, however, that 95 and 50% MCP home ranges for the 2 female Wolverines incidentally killed by trappers had the highest road densities among our study animals (95% MCP = 0.55 and 1.15 km/km^2, 50% MCP = 0.43 and 1.68 km/km^2). Excluding these two animals, mean road densities (SE) within the 95 and 50% MCPs were 0.27 (0.06) and 0.04 (0.02) km/km^2, respectively, and were significantly different ($z = -2.02$, $P = 0.043$). The road density within the one denning female's (F04) 50% MCP HR_A was 0.

Study animal F04 was confirmed to be a reproductive female when lactation was noted at the time of her capture on 23 March 2004. We subsequently located her den site and observed her bringing food to the den and moving a kit between two structures at the den site. Three different structures used at this den site were located approximately 300 m from each other on a hill in second-growth timber. FRI data described the stand as 60% Black Spruce, 30% Jack Pine, and 10% poplar (Trembling Aspen), 12 m in height, 70% stocking, and 83 years of age. This stand was located within the perimeter of a 104 km^2 burn that occurred in 1956 (OMNR, unpublished data). One structure at the den site consisted of a complex of large boulders approximately 60 m long and 30 m wide. The largest boulder was about 4 m in diameter and there were many large spaces under the boulders. Another structure, near the top of the hill at the edge of a small opening in the forest, consisted of fallen trees covered with snow. The third structure was in a dense stand of trees and could not be observed from the aircraft. Only the boulder structure was visited on the ground after the snow melted. The hill where the den site was located was 7 km from the nearest forestry road and cutblock, 5 km from a lightly used mining trail, and approximately 10 km from active logging.

Discussion

For six of our study animals, the 95% MCP HR based on VHF locations only were within the limits for VHF-derived home range estimates reported by other researchers, regardless of how home range size was calculated (see: Mulders 2000*; Krebs et al. 2007; Persson et al. 2009). For all of our study animals, home range estimates (HR_A) based on a combination of VHF and Argos locations indicate that home range sizes for Wolverines in lowland boreal forest in Ontario are similar to those in other habitat types. Moreover, the larger size of male home ranges compared to those of females and the overlap in male and female home ranges (Figure 1) were consistent with patterns reported from other areas (Banci 1994).

The 95% HR_A home range for the lactating female (F04) in this study was near the upper limit of home range size for reproductive females using similar data sets (see Mulders 2000*; Krebs et al. 2007; Persson et al. 2009). The presence of a lactating female in our study area and the results of a subsequent aerial survey for Wolverine tracks in a larger area centered on our study area (Magoun et al. 2007), indicated that the Wolverine population in our study area was a resident, reproductive population near the southern edge of the species' distribution in Ontario.

The presence of snow-covered boulders and fallen trees at F04's reproductive den site is not surprising given the description of typical reproductive dens from other study areas (Magoun and Copeland 1998). However, the occurrence of large boulder complexes is much more limited in our study area than in montane habitats where reproductive dens have been described. Moreover, because the boreal forest does not support the deep, wind-hardened snowdrifts used for reproductive dens in tundra (Magoun 1985), structures within the snow layer such as trees and boulders are likely to be critical features of Wolverine dens in lowland boreal forests. Given the potential importance of boulder complexes in our study as potential reproductive den sites for Wolverines in lowland boreal forest, we recommend that the distribution and characteristics of these boulder complexes be documented in future studies of potential Wolverine habitat.

Our results also suggest that road densities may affect selection of home ranges by Wolverines, in accordance with the broader distribution patterns of this species in the area (Magoun et al. 2007; Bowman et al. 2010). Although Wolverines are generally reported to prefer undeveloped areas, we could find no studies that reported road densities within Wolverine home ranges (Banci 1994; May et al. 2006). Habitat modeling work by Carroll et al. (2001) reported that Wolverine occurrences were negatively associated with

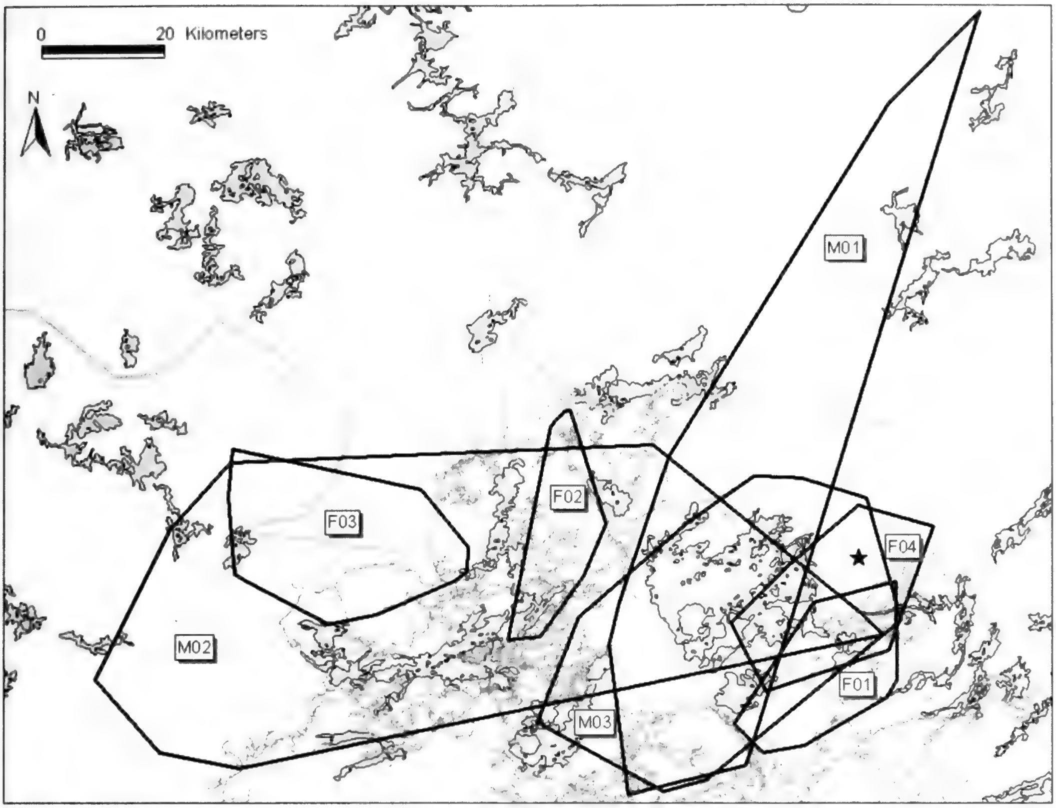


FIGURE 1. Locations of 100% MCP home ranges for 3 male (M) and 4 female (F) Wolverines (*Gulo gulo*) in Ontario, Canada. Locations were derived with a combination of Argos satellite and VHF radio telemetry during December 2003 to October 2004. The road network (mostly logging roads) is depicted by solid gray lines and lakes are shown in gray. The star indicates the location of female F04's den. The thick gray line crossing at approximately the mid point indicates the northern limit of commercial logging.

road densities >1.7 km/km^2. However, Rowland et al. (2003) suggested that this threshold may be lower, because Wolverine abundance estimates in their watershed-scale models varied between low road densities (<0.44 km/km^2) and moderate road densities (0.44 – 1.06 km/km^2). Results from our study in lowland boreal forests of central Canada are consistent with their predictions for the interior northwest area of the United States (Rowland et al. 2003). The mean road density for 95% MCP HR_A for all Wolverines in this study was 0.43 km/km^2, and for the two Wolverines whose home ranges had higher road densities than the suggested threshold of 0.44 km/km^2, the risk of mortality due to anthropogenic factors appeared to increase.

Roads may also have an important influence on den site selection. May (2007) found that the mean distance (SE) from natal dens to public and private roads was 7461 (206) m and 3058 (120) m, respectively. The reproductive den of Wolverine F04 in our study was 7 km from an active logging road and 5 km from a lightly used mining trail. In central lowland boreal forests maintaining low road densities (<0.44 km/km^2) and large areas of undisturbed forest to provide isolated denning sites may be particularly important to Wolverines because they cannot select high-elevation alpine habitats to reduce predation risk and human disturbance (Krebs et al. 2007), as do populations in the West. Further study of movements and den-site selection by Wolverines in this region is needed to determine if Wolverines adjust their movements and home ranges to accommodate changes in land use patterns.

Acknowledgments

Project funding was provided by the Ontario Living Legacy Trust Fund, Wildlife Conservation Society Canada, The Wolverine Foundation, Inc., and the Ontario Ministry of Natural Resources. We could not have accomplished our fieldwork without the dedicated support of field technicians Richard Klafki and Shannon Walshe who were with the project both years.

Geoff and Catherine Lipsett-Moore were instrumental in project set-up and design. Additional field technicians who provided valuable support were Marek Klich, Laura Bruce, and Tim Carter. We also thank Dr. Heather Reid who served as our advising veterinarian. The support of staff at the Red Lake OMNR office and from the Red Lake and Ear Falls trappers was also greatly appreciated. Additional thanks to K. B. Aubry and T. Jung for their constructive review comments on the manuscript.

Documents Cited (marked * in the text)

Hooge, P. N., and **B. Eichenlaub.** 2000. Animal movement extension to ArcView. Alaska Science Center – Biological Science Office, USGS. Anchorage, Alaska, USA.

Mulders, R. 2000. Wolverine ecology, distribution, and productivity in the Slave Geological Province. Final Report to the West Kitikmeot/Slave Study Society. Department of Resources, Wildlife and Economic Development, Government of the Northwest Territories, Yellowknife, Northwest Territories, Canada. 90 pages.

Literature Cited

Banci, V. 1987. Ecology and behaviour of wolverine in Yukon. M.Sc. thesis, Simon Fraser University, Burnaby, British Columbia, Canada. 178 pages.

Banci, V. 1994. Wolverine. Pages. 99-127 *in* The scientific basis for conserving forest carnivores: American marten, fisher, lynx and wolverine in the western United States. *Edited by* L. F. Ruggiero, K. B. Aubry, S. W. Buskirk, L. J. Lyon, and W. J. Zielinski USDA Forest Service, General Technical Report RM-254, Fort Collins, Colorado, USA.

Bowman, J., J. C. Ray, A. J. Magoun, D. S. Johnson, and **F. N. Dawson.** 2010. Roads, logging, and the large-mammal community of an eastern Canadian boreal forest. Canadian Journal of Zoology. 88: 454-467.

Carroll, C., R. F. Noss, and **P. C. Paquet.** 2001. Carnivores as focal species for conservation planning in the Rocky Mountain region. Ecological Applications 11: 961-980.

Copeland, J. P. 1996. Biology of the wolverine in central Idaho. M.Sc. thesis, University of Idaho, Moscow, Idaho, U.S.A. 138 pages.

De Solla, S. R., R. Bonduriansky, and **R. J. Brooks.** 1999. Eliminating autocorrelation reduces biological relevance of home range estimates. Journal of Animal Ecology 68: 221-234.

Gardner, C. L. 1985. The ecology of wolverines in south-central Alaska. M.Sc. thesis, University of Alaska, Fairbanks, Alaska, USA. 82 pages.

Golden, H. N., B. S. Shults, and **K. E. Kunkel.** 2002. Immobilization of wolverines with Telazol from a helicopter. Wildlife Society Bulletin 30: 492-497.

Harris, S., W. J. Cresswell, P. G. Forde, W. J. Trewhella, T. Woollard, and **S. Wray.** 1990. Home-range analysis using radio-tracking data – a review of problems and techniques particularly as applied to the study of mammals. Mammal Review 20: 97-123.

Hornocker, M. G., and **H. S. Hash.** 1981. Ecology of the wolverine in northwestern Montana. Canadian Journal of Zoology 59: 1286-1301.

Keating, K. A., W. G. Brewster, and **C. H. Key**. 1991. Satellite telemetry: performance of animal-tracking systems. Journal of Wildlife Management 55: 160-171.

Krebs, J. A., E. C. Lofroth, and **I. Parfitt.** 2007. Multiscale habitat use by wolverines in British Columbia. Journal of Wildlife Management 71: 2180-2192.

Lofroth, E. C., R. Klafki, J. A. Krebs, and **D. Lewis.** 2008. Evaluation of live-capture techniques for free-ranging wolverines. Journal of Wildlife Management 72: 1253-1261.

Magoun, A. J. 1985. Population characteristics, ecology, and management of wolverines in northwestern Alaska. Ph.D. dissertation, University of Alaska, Fairbanks, Alaska, USA. 197 pages.

Magoun, A. J., and **J. P. Copeland.** 1998. Characteristics of wolverine reproductive den sites. Journal of Wildlife Management 62: 1313-1320.

Magoun, A. J., J. C. Ray, D. S. Johnson, P. Valkenburg, F. N. Dawson, and **J. Bowman.** 2007. Modeling wolverine occurrence using aerial surveys of tracks in snow. Journal of Wildlife Management 71: 2221-2229.

May, R., A. Landa, J. van Dijk, J. D. C. Linnell, and **R. Andersen.** 2006. Impact of infrastructure on habitat selection of wolverines *Gulo gulo*. Wildlife Biology 12: 285-295.

May, R. 2007. Spatial ecology of wolverines in Scandinavia. Ph.D. dissertation, Norwegian University of Science and Technology, Trondheim, Norway. 192 pages.

Otis, D. L., and **G. C. White.** 1999. Autocorrelation of location estimates and the analysis of radiotracking data. Journal of Wildlife Management 63: 1039-1044.

Persson, J., P. Wedholm, and **P. Segerström.** 2009. Space use and territoriality of wolverines (*Gulo gulo*) in northern Scandinavia. European Journal of Wildlife Research 56: 49-57.

Rowland, M. M., M. J. Wisdom, D. H. Johnson, B. C. Wales, J. P. Copeland, and **F. B. Edelmann.** 2003. Evaluation of landscape models for wolverines in the interior northwest, United States of America. Journal of Mammalogy 84: 92-105.

Slough, B. G. 2007. Status of the wolverine *Gulo gulo* in Canada. Wildlife Biology 13(Suppl.2): 76-82.

Swihart, R. K., and **N. A. Slade.** 1985. Influence of sampling interval on estimates of home-range size. Journal of Wildlife Management 49: 1019-1025.

Swihart, R. K., and **N. A. Slade.** 1997. On testing for independence of animal movements. Journal of Agricultural, Biological, and Environmental Statistics 2: 48-63.

Whitman, J. S., W. B. Ballard, and **C. L. Gardner.** 1986. Home range and habitat use by wolverines in southcentral Alaska. Journal of Wildlife Management 50: 460-462.

Received 15 January 2010
Accepted 3 August 2010

Aerial Surveys Do Not Reliably Survey Boreal-nesting Shorebirds

KYLE H. ELLIOTT[1,3], PAUL A. SMITH,[2] and VICTORIA H. JOHNSTON[1]

[1] Canadian Wildlife Service, P.O. Box 2310, Yellowknife Northwest Territories X1A 2P7 Canada
[2] National Wildlife Research Centre, Carleton University, Ottawa, Ontario K1A 0H3 Canada
[3] Corresponding author; e-mail: haliaeetus@gmail.com

Elliott, Kyle H., Paul A. Smith, and Victoria H. Johnston. 2010 Aerial surveys do not reliably survey boreal-nesting shorebirds. Canadian Field-Naturalist 124(2): 145–150.

Aerial surveys have been used as a method for surveying boreal-nesting shorebirds, which breed in difficult-to-access terrain; however, the fraction of breeding birds observed from the air is unknown. We investigated rates of detection by conducting simultaneous air and ground surveys for shorebirds at three sites in the boreal forest of the Northwest Territories, Canada, in 2007. Helicopter surveys included both pond-based surveys where the helicopter flew around the perimeter of each wetland and transect-based surveys where observers recorded birds seen on line transects. Ground surveys involved intensive observation, territory mapping and nest searching in 5 km^2 of plots over a period of 5-6 weeks. Shorebird densities observed from the helicopter were highest near large bodies of water. No shorebirds were observed over closed forest despite breeding densities on ground surveys being highest in closed forest. Detection rates were very low, varied among species and aerial survey types, and were inconsistent over time. Ground-based observations showed that the shorebirds often did not flush in response to the helicopter passing overhead. Owing to poor rates of detection, we conclude that helicopter surveys are not an appropriate method for surveying breeding shorebirds in boreal habitats, but may have some utility for monitoring birds' use of stop-over locations.

Key Words: Lesser Yellowlegs, *Tringa flavipes*, Wilson's Snipe, *Gallinago delicata*, Solitary Sandpiper, *Tringa solitaria*, Aerial survey, shorebirds, Northwest Territories.

Due to inaccessibility, status and trends of many bird populations in the northern boreal forest are generally poorly known (Erskine 1974; Sinclair et al. 2004*). However, large numbers of waterbirds breed there, and migration counts suggest declines in breeding populations for most boreal-nesting shorebirds, including Lesser Yellowlegs (*Tringa flavipes*), Wilson's Snipe (*Gallinago delicata*) and Solitary Sandpiper (*Tringa solitaria*) (Morrison et al. 2006, Bart et al. 2007). Because travel on the ground through the boreal forest is so difficult, the data available for boreal waterbirds are almost entirely based upon aerial surveys (e.g., Bolduc et al. 2008; see Erskine 1974). Those surveys are undertaken regularly by the US Fish and Wildlife Service and Canadian Wildlife Service and which yield indices of abundance and information on habitat use (e.g., USFWS 2002*). Although those surveys were traditionally limited to waterfowl, shorebirds have recently been included (Skagen et al. 2003, Sinclair et al. 2004*). Although large birds, such as waterfowl and raptors, can be accurately surveyed from the air (Gaston et al. 1986, Smith 1995*; Anthony et al. 1999; Gilchrist and Mallory 2005; Barnhill et al. 2005), aerial surveys are seldom used for small birds and there is little information on the accuracy of aerial surveys for shorebirds (but see Nebel et al. 2008). Furthermore, most boreal birds, including shorebirds, are detected by ear, which is not possible during aerial surveys. Specifically, the concordance between aerial observations and the actual number of breeding birds (i.e., the detection rate) has not been established for boreal-nesting shorebirds, or for most small birds. With no objective measurement of bias, the reliability of aerial surveys for shorebirds is unknown (Smit 1989). In this study, we attempted to measure detection rates for aerial surveys of three species of boreal-nesting shorebirds, and examined what parameters affected detection.

Methods

Our study area stretched across the Northwest Territories from the Alberta border to Inuvik. As such, habitat varied from aspen parkland in the south to the treeline in the north. Nonetheless, the majority of habitat could be classified as within the Taiga Shield (Western Taiga Shield Ecoprovince) or Taiga Plains Ecozones, with one of the intensive survey plots and the middle sections of the pipeline survey route being within the Taiga Plains Ecozone and the remainder being within the Taiga Shield Ecozone. We selected the Yellowknife intensive plots as representative of the Taiga Shield. Topography was dominated by outcrops of bedrock that cover 25-30% of the land surface. The terrain was flat to slightly rolling between outcrops and is composed of glacial deposits of clay, silt, sand, and gravel. It contained a patchwork of dry Jack Pine forest (*Pinus banksiana*) on outcrops, mesic birch (*Betula* spp.)-White Spruce (*Picea glauca*)-aspen (*Populus* spp.) stands and alder (*Alnus* spp.) thickets, and low, wet Black Spruce (*Picea mariana*)-Tamarack (*Larix laricina*) bogs and willow (*Salix* spp.) thickets. Wetlands were common, with typical ponds ranging

in size from 0.1 to 18.2 ha. Some natural ponds had abrupt shorelines of outcrop or shrubs, but most were bordered by floating sedge mats of various widths. We selected the Fort Simpson intensive plot as representative of the Taiga Flats. Topography was flat and dominated by Black Spruce forest, open muskeg, flooded swamps and ponds. Mesic uplands forested with white spruce, jack pine, and a variety of deciduous species were also present.

In 2005, we conducted aerial surveys along a continuous overland transect near the Mackenzie River (the proposed route for the Mackenzie Gas Pipeline) and along the Mackenzie River between Norman Wells and Inuvik, 24-27 May and 3-6 June. In 2006, surveys were conducted at 15 locations along the pipeline route between the Alberta border and Norman Wells, 19-23 May, selected non-randomly to include areas with open wetlands (Figure 1). These surveys consisted of five transects parallel to the proposed pipeline route, each 10 km long and separated by 500 m. An additional 30 transects were completed along the Mackenzie River in 2006 (Figure 1). In 2007, we conducted aerial transect surveys within the two Yellowknife intensive study plots (described below) and on two additional nearby 22.5 km^2 plots on 23 May and 2 June. We also conducted aerial transect surveys on four 25 km^2 plots near Fort Simpson, including a 1 km^2 intensive study site (described below) on 25 May and 6 June. In both 2006 and 2007, we also conducted "pond surveys", where we followed the shoreline of the larger ponds within the study area or, in smaller ponds or wetlands, flew down the middle of the water body.

Surveys were flown in a Bell 206 helicopter, with one observer located in the front passenger seat and one in the rear behind the pilot. Observations were recorded with handheld digital voice recorders. The location of bird sightings was established by logging a timed location of the aircraft using GPS and recording the time of bird sightings on the voice recorders, which recorded the time of each observation. Transect surveys were flown at a speed of 80km/h at a height of 30m above the ground. For the purpose of determining detection ratios, transects ran north–south along the long axis of the intensive plots, with 500m between the centre lines. Pond surveys were initially flown lower and slower (tree height level and 40 km/hr). After a short initial trial, pond surveys were changed and became identical to transect survey speed and height due to safety concerns. We recorded all sightings within 100m of either side of the aircraft, as that is the standard width for aerial shorebird surveys in the Arctic. In both transect and pond surveys, shorebirds were identified to species where possible or were otherwise assigned to size classes. Calidrids, Spotted Sandpipers (*Actitis macularia*) and phalaropes were grouped as "small" shorebirds. American Golden-Plovers (*Pluvialis dominica*), Killdeer (*Charadrius vociferus*), Lesser Yellowlegs, Solitary Sandpipers, Wilson's Snipe and dowitchers were grouped as "medium" shorebirds. Whimbrel (*Numenius phaeopus*) and Hudsonian Godwits (*Limosa haemastica*) were grouped as "large" shorebirds. Habitat within the aerial survey plots was classified broadly as pond, taiga, closed forest, and other, and boundaries of each of these habitat types within the surveyed areas were estimated on a GIS layer using Google Earth data. Georeferenced observations of birds were overlain on this layer to determine coarse-level habitat associations.

We carried out two types of ground surveys. In 2005, we completed 17 ground surveys away from the river and 12 along the river's edge. All ground surveys were along the flight path of the helicopter. Ground surveys were 10-minute point counts (2005, away from the river) or transects (2005, along the river; 2006, all surveys) where observers recorded all birds seen or heard. As the topography limited straight-line travel and distance-sampling, the transects consisted of random walkabouts along approximately straight lines by the observers and were roughly 10 min in duration and 500 m in length. More intensive ground surveys were conducted at two sites. Two observers intensively surveyed a 1 km^2 plot near Fort Simpson 18 May to 21 June 2007 (264 person-hours) and an additional two observers surveyed two 2 km^2 plots near Yellowknife 7 May to 28 June 2007 (344 person-hours). As few nests were found (six in total), breeding territories were delineated by territory mapping. Locations of territorial (displaying or mate-defense) and copulating birds were recorded with GPS. Individuals were differentiated by simultaneous detections. GPS locations, mapped territory boundaries and corresponding notes were used to determine the number of territories on the intensive survey plots. We determined the location of territory centroids for birds near the boundary of the plots, but because of low densities, this complication was rare. For each intensively surveyed plot, we calculated detection rates as the number of birds counted during aerial surveys divided by the actual number of territories observed during intensive surveys (Anthony et al. 1999; Bart and Earnst 2002). As we expect more than one bird per territory on average, "ideal" detection rates (if all birds present are seen) would be close to two. Detection rates were calculated for each type of aerial survey and for each aerial survey date. Shorebird behavior in response to aerial surveys was investigated by positioning observers on the ground along aerial flight lines at known shorebird locations. Shorebird response (if, when, and where a bird flushed in relation to the helicopter) was recorded. These observations were compared to the aerial survey results to determine if flushed birds were spotted by the aerial surveyors. Values are reported ± SE.

Results

Aerial surveys away from the Mackenzie River ("Mackenzie Gas Pipeline route") accounted for many

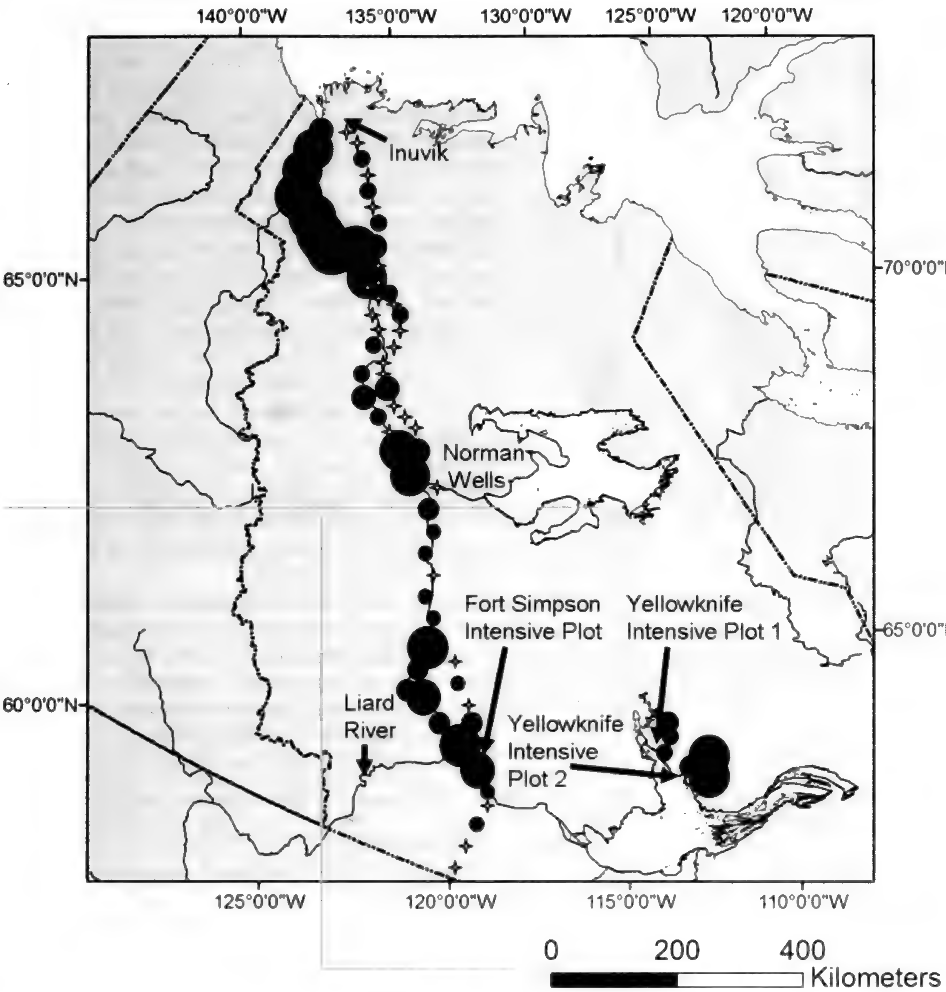


FIGURE 1. Shorebird densities in the boreal forest of the Northwest Territories, as detected during aerial surveys. Aerial surveys covered the Mackenzie River, the overland portions of the proposed Mackenzie Gas Pipeline route, survey blocks near Yellowknife, and three intensive plots. Densities are 0 (crosses), 0-0.1 (small circles), 0.1-0.5 (medium-small circles), 0.5-1.0 (medium-large circles) and 1.0+ (large circles) birds per km^2.

fewer birds and lower diversity than surveys along the river (Figure 1); Killdeer, Least Sandpiper (*Calidris minutilla*), Red-necked Phalarope (*Phalaropus lobatus*), Sanderling (*Calidris alba*), Semipalmated Plover (*Charadrius semipalmatus*), Semipalmated Sandpiper (*Calidris pusilla*), Whimbrel and White-rumped Sandpiper (*Calidris fuscicollis*) were all recorded only along the river sections whereas Hudsonian Godwit was the only species recorded away from the river. Highest concentrations were seen on the northern survey sections of the river, where birds may have still been staging or migrating northward in late May and early June or where two rivers or river channels met (e.g., intersection of the Liard River, Figure. 1). Many of the birds seen on the river surveys were clearly non-breeders. The higher densities seen on the river appeared to occur because non-breeding birds tended to congregate at these locations, making them easier to disturb and detect from the helicopter. No birds were detected by aerial surveys over closed forest, but 19% of Solitary Sandpipers, 18% of Lesser Yellowlegs and 41% of Wilson's Snipe were recorded at wetlands, and 31% of Solitary Sandpipers, 83% of Lesser Yellowlegs and 57% of Wilson's Snipe were recorded within 50 m of open water. The remaining sightings were over "other" habitats, which includes drier meadows and cleared areas. In general, the number of shorebirds seen increased with waterbody size (Figure 2).

TABLE 1. Total birds observed during "pond" and "transect" type aerial surveys of a 1 km² "intensive plot" (Fort Simpson) and two 2 km² "intensive plots" (Yellowknife), and detection ratios (DR, observed number of birds divided by actual number of territories present, shown in parentheses) for Lesser Yellowlegs (LEYE), Wilson's Snipe (WISN), Solitary Sandpipers (SOSA) and all shorebirds (ALL). The total number of breeding territories in the plot, estimated from intensive ground surveys is also shown ("Total Ground"). "ALL" includes shorebirds not identified to species. No detection rate was calculated for locations without birds observed during the ground surveys.

	Fort Simpson					Yellowknife (two separate plots)						
Date	25 May		6 June		Total	23 May	2 June	Total	23 May	2 June	Total	
Type	Transect	Pond	Transect	Pond	Ground	Transect	Pond	Ground	Transect	Transect	Pond	Ground
LEYE	1 (0.25)	0 (0)	0 (0)	0 (0)	4	6 (1.2)	2 (0.4)	5	6 (0.75)	0 (0)	13 (1.6)	8
WISN	0 (0)	0 (0)	0 (0)	2 (0.09)	23	0 (0)	1 (0.08)	12	0 (0)	1 (0.09)	0 (0)	11
SOSA	0 (0)	0 (0.08)	0 (0)	0 (0)	12	0 (-)	0 (-)	0	0 (-)	0 (-)	3 (-)	0
ALL	1 (0.03)	0 (0.05	0 (0)	3 (0.08)	39	7 (0.41)	3 (0.18)	17	7 (0.37)	1 (0.05)	18 (0.95)	19

Ground transects along the Mackenzie Valley reported 1.0 ± 0.3 Solitary Sandpipers and 15.5 ± 2.6 total shorebirds per kilometer whereas aerial transects reported 0.7 ± 0.1 Solitary Sandpipers and 1.0 ± 0.2 total shorebirds per kilometer. Away from the river, ground transects reported 4.0 ± 1.1 total shorebirds per kilometer whereas aerial surveys reported 0.3 ± 0.1 (transect) and 0.8 ± 0.2 (pond) total shorebirds per kilometer. Thus, aerial surveys detected fewer birds than ground surveys, and, within aerial surveys, pond surveys detected more birds than transect surveys (see also Table 1). This trend was true for Lesser Yellowlegs, Solitary Sandpiper, and Wilson's Snipe.

Detection rates for aerial surveys varied greatly between species (Lesser Yellowlegs: 0.47 ± 0.19; Wilson's Snipe 0.029 ± 0.014; Solitary Sandpiper 0.00 ± 0.00; Table 1). Detection rates for Wilson's Snipes were consistent, but extremely low (between 0.1 and 0), but rates for Lesser Yellowlegs varied with survey type and date of survey (Table 1). Detection rates greater than 1 occurred on several occasions for Lesser Yellowlegs, which often flew erratically in response to the helicopter and were possibly double-counted (Table 1).

Observations on the ground at the time the helicopters flew past supported the low and variable detection rates. Often, if birds flushed at all, they did so a few seconds after the helicopter passed by (Table 2). The helicopter surveys did not flush many of the birds on the ground, at least until after the helicopter had already passed by, and that even those that were flushed were often missed (Table 2).

Discussion

Two aerial survey methods were tested during this study: transect-based and pond-based surveys. Transect-based surveys took more time and fuel flying over closed forest habitats where no shorebirds were sighted. Pond-based surveys recorded more shorebirds but likely had a higher rate of double-counting, and involved safety risks due to sharp turns at slow speeds. Both survey types had low (in many cases, null) and variable detection rates. Ground observations showed that it was not observer error or inexperience that led to these low detection rates. In the majority of cases, birds were missed because they either did not flush until the helicopter had passed, or they did not flush at all. For example, in over half of surveys, no Wilson's Snipe were seen from the air even though during the surveys observers on the ground watched individuals that were below or adjacent to the helicopter flight path (Table 2). Other shorebird species were more often counted from the air, but counts varied greatly within and between survey types and dates (Table 1).

Wetland-based surveys are used by the USFWS and CWS to obtain population estimates of boreal breeding waterfowl (Smith 1995*, USFWS 2002*). However, the methodology restricts surveys to wetlands that are 1 ha or greater in size and relies on the fact that most of the waterfowl are on the water (Smith 1995*; USFWS 2002*). Even for those larger birds, detection probabilities for aerial

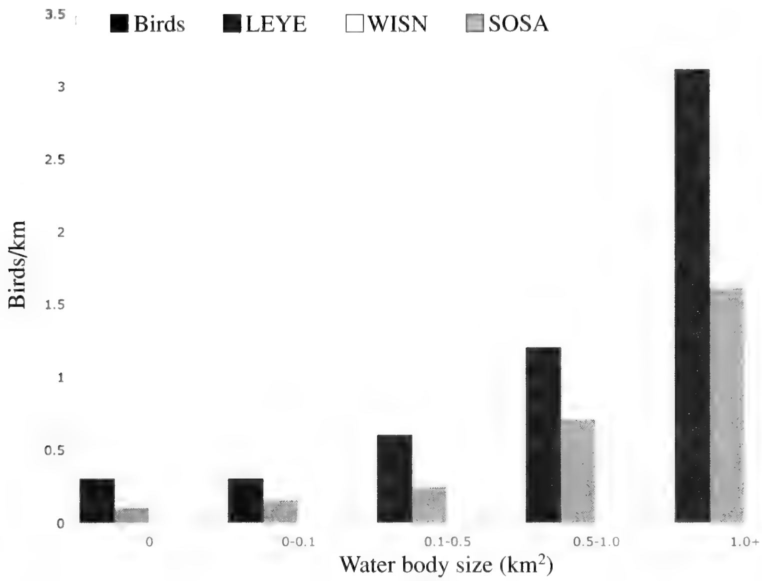


FIGURE 2. Birds detected per kilometer on aerial surveys over different-sized water bodies. River surveys excluded.

TABLE 2. Responses of resting or foraging Lesser Yellowlegs (LEYE), Wilson's Snipe (WISN) and Solitary Sandpipers (SOSA) to helicopter passes, as observed by ground observers. "Distance" represents the horizontal distance of the closest approach by the helicopter. Birds that flushed after the helicopter passed are shown with an asterisk. The column "observed" denotes whether the birds were recorded by aerial surveyors.

LEYE	WISN	SOSA	Distance	Flushed?	Observed?
2	3		50 m	All	None
2			Overhead	None	None
4	2		100 m	None	None
4	2		50 m	1 WISN; all*	None
		2	Overhead	1 SOSA	None
	3		50 m	1 WISN*	None
		1	Overhead	None	None

surveys vary according to survey date, species, group size, observer and observer position within the aircraft (Rumble and Flake 1982; Gabor et al. 1995; Naugle et al. 2000; Conroy et al. 2008). Shorebirds are often present on tiny wetlands, and nest territories include, but are not restricted to these wetlands. Birds are usually beside rather than on the water, where they are harder to detect; therefore, one aerial flight over a wetland will miss many shorebirds. In contrast, circling the wetlands increases the chances of double-counting and could be less safe than traditional transect flying.

Species-habitat associations complicated the sampling of boreal-nesting shorebirds using aerial surveys. We found that the number of shorebirds detected increased with the size of the water body, and we recorded no shorebirds over closed forest. This bias in detection rate among habitats could result in misleading information. For example, if birds feeding on large water bodies are non-breeders, aerial surveys may suggest highest population levels in years when breeding failure is highest (i.e., when large congregations of non-breeders are on large water bodies). Conversely, aerial surveys may be useful for surveying non-breeding shorebirds at stop-over or wintering sites where they are largely out in the open or near large waterbodies (Morrison et al. 2004; Nebel et al. 2008).

In conclusion, detection rates for boreal-nesting shorebirds during aerial surveys were low, and varied among species, survey types, habitats and even dates. The variability was sufficiently high that the results of aerial surveys are of little value for estimating population size and trends for shorebirds breeding in boreal habitats. Aerial surveys may be useful for monitoring relative importance of sites to shorebirds, or may be

used to track abundance indices at large, open staging sites. However, variability in detection may be problematic even for these coarse indices. Furthermore, aerial surveys have a large carbon footprint, and the positive benefits of that footprint (public awareness or policy change) would need to be weighed against negative costs (miniscule increase in emissions) for each boreal shorebird species (e.g., Grémillet 2004). We recommend that boreal aerial surveys for shorebirds be replaced with systematic ground surveys provided that they include the adoption of dual-observer or double sampling methods with statistical rigor and site-specific studies of detection rates (Crête et al. 1991, Bart and Earnst 2002; Collins 2007; Conroy et al. 2008).

Acknowledgments

We thank our field assistants K. Andruchow, S. Dauncey, C. Wood and especially T. Marsh. J. Bart and L. Pirie provided important discussions about aerial survey design. We also thank the excellent pilots at Great Slave Helicopters (Fort Simpson and Yellowknife) and Canadian Helicopters (Norman Wells) for their expert maneuvering. The manuscript benefited from comments by A. Erskine, G. Smith, and an anonymous reviewer.

Documents Cited (marked * in text)

Sinclair, P., Y. Aubry, J. Bart, V. Johnston, R. Lanctot, B. McCaffrey, K. Ros, P. Smith, and **L. Tibbitts.** 2004. Boreal shorebirds: an assessment of conservation status and potential for population monitoring. http://www.bsc-eoc.org/download/Borealshorebirdmonitorpaper.pdf. Accessed 1 September 2009.

Smith, G. W. 1995. A Critical review of the aerial and ground surveys of breeding waterfowl in North America. USDI-NBS Biological Science Report 5. 252 pages.

U.S. Fish and Wildlife Service. 2002. Waterfowl breeding population survey for Northern Alberta, Northeastern British Columbia, and the Northwest Territories (Mackenzie District). U.S. Fish and Wildlife Service, Laurel, Maryland. Available at: http://www.fws.gov/migratorybirds/reports/wps02/May/nwt.pdf. Accessed 1 September 2009.

Literature Cited

Anthony, R. G., M. G. Garrett, and **F. B. Isaacs.** 1999. Double-survey estimates of bald eagle populations in Oregon. Journal of Wildlife Management 63: 794-802.

Barnhill, R. A., D. Weyer, W. F. Young, K. G. Smith, and **D. James.** 2005. Breeding biology of Jabirus (*Jabiru mycteria*) in Belize. Wilson Bulletin 117: 142-153.

Bart, J., and **S. Earnst**. 2002. Double sampling to estimate density and population trends in birds. Auk 119: 36-45.

Bart, J., S. Brown, B. Harrington, and **R. I. G. Morrison.** 2007. Survey trends of North American shorebirds: population declines or shifting distributions? Journal of Avian Biology 38: 73-82.

Bolduc, F., S. Lapointe, and **B. Gagnon.** 2008. Common Goldeneye breeding in the eastern Canadian boreal forest: factors affecting productivity estimates. Waterbirds 31: 42-51.

Collins, B. T. 2007. Guidelines for using double sampling in avian population monitoring. Auk 124: 1373-1387.

Conroy, M. J., J. T. Peterson, O. L. Bass, C. J. Fonnesbeck, J. E. Howell, C. T. Moore, and **J. P. Runge.** 2008. Sources of variation in detection of wading birds from aerial surveys in the Florida Everglades. Auk 125: 731-743.

Crête, M., D. Vandal, L.-P. Rivest, and **F. Potvin.** 1991. Double counts in aerial surveys to estimate polar bear numbers during the ice-free period. Arctic 44: 275-278.

Erskine, A. J. 1974. Off into the wet green yonder: birds and plants of a boreal bog. Blue Jay 32: 33-37.

Gabor, T. S., T. R. Gadawski, R. K. Ross, R. S. Rempl, and **D. W. Kroeker.** 1995. Visbility bias of waterfowl brood surveys using helicopters in the Great Clay Belt of Northern Ontario. Journal of Field Ornithology 66: 81-87.

Gaston, A. J., R. Decker, F. G. Cooch, and **A. Reed.** 1986. The distribution of larger species of birds breeding on the coasts of Foxe Basin and northern Hudson Bay, Canada. Arctic 39: 285-298.

Gilchrist, H. G., and **M. L. Mallory.** 2005. Declines in abundance and distribution of the ivory gull (*Pagophila eburnea*) in Arctic Canada. Biological Conservation 121: 303-309.

Grémillet, D. 2008. Paradox of flying to meetings to protect the environment. Nature 455: 1175.

Morrison, R. I. G., R. K. Ross, and **L. J. Niles.** 2004. Declines in wintering populations of Red Knots in southern South America. Condor 1006: 60–70.

Morrison, R. I. G., B. J. McCaffery, R. E. Gill, S. K. Skagen, S. L. Jones, G. W. Page, C. L. Gratto-Trevor, and **B. A. Andres.** 2006. Population estimates of North American shorebirds, 2006. Wader Study Group Bulletin 111: 66–84.

Naugle, D. E., R. R. Johnson, T. R. Cooper, M. M. Holland, and **K. F. Higgins.** 2000. Temporal distribution of waterfowl in eastern South Dakota: implications for aerial surveys. Waterbirds 20: 177-183.

Nebel, S., J. L. Porter, and **R. T. Kingsford.** 2008. Long-term trends of shorebird populations in eastern Australia and impacts of freshwater extraction. Biological Conservation 141: 971-980.

Rumble, M. A., and **L. D. Flake.** 1982. A comparison of two waterfowl brood survey techniques. Journal of Wildlife Management 46: 1048-1053.

Skagen, S. K., J. Bart, B. Andres, S. Brown, G. Donaldson, B. Harrington, V. Johnston, S. L. Jones, and **R. I. G. Morrison.** 2003. Monitoring the shorebirds of North America: towards a unified approach. Wader Study Group Bulletin 100: 102-104.

Smit, C. J. 1989. Perspectives in using shorebird counts for assessing long-term changes in wader numbers in the Wadden Sea. Helgoland Marine Research 43: 367-383.

Received 4 February 2010
Accepted 16 September 2010

Rosa rugosa as an Invader of Coastal Sand Dunes of Cape Breton Island and Mainland of Nova Scotia

NICHOLAS HILL, LEAH BEVERIDGE, ANDREA FLYNN, and DAVID J. GARBARY

Department of Biology, St. Francis Xavier University, Antigonish, Nova Scotia B2G 2W5 Canada; e-mail: dgarbary@gmail.com

Hill, Nicholas, Leah Beveridge, Andrea Flynn, and David J. Garbary. 2010. *Rosa rugosa*. as an Invader of Coastal Sand Dunes of Cape Breton Island and Mainland of Nova Scotia. Canadian Field-Naturalist 124(2): 151–158.

Rosa rugosa is described for the first time as an invasive species associated with coastal sand dunes in Atlantic Canada. Our surveys of 24 beaches on western Cape Breton Island and the mainland of northern Nova Scotia from Cheticamp to Fox Harbour showed that 11 of the dune systems (ca. 45%) were colonized. This was more prevalent in Cape Breton where *R. rugosa* occurred on 9 of 13 systems, whereas only 2 of 9 mainland systems were colonized. Four dunes (three in Cape Breton) were considered heavily colonized with 0.4 – 8.8% of the dune area with cover of *R. rugosa*. These beaches had 12 – 42 independent clumps with almost monospecific stands over 90 % cover. In general, heavily colonized beaches were found adjacent to communities where extensive domestic planting and hedges of *R. rugosa* occurred and where escapes onto roadsides had occurred. In most colonized beach systems, rhizomes from clones extended 1 – 5 m to produce younger shoots. The absence of *Ammophila breviligulata, Lathyrus maritimus* and *Myrica pensylvanica*, from the interior of many clumps of *R. rugosa* suggests that native dune communities are being negatively impacted. This exacerbates dune integrity already compromised by impacts of sea level rise.

Key Words: *Rosa rugosa*, invasive plants, sand dunes, Gulf of St. Lawrence, Cape Breton, Nova Scotia.

With an origin in eastern Asia, *Rosa rugosa* Thunb. has become widely naturalized in North America and Europe from ornamental plantings (Roland and Smith 1969; Bruun 2005). In both North America and Europe the species has been recognized as an invasive species. In northwestern Europe, in particular shores facing the North Sea and Baltic Sea, *R. rugosa* has been a major invader of sand dune ecosystems, and has become the most abundant alien species in this habitat in both Denmark and Germany (Bruun 2005; Weidema 2006; Isermann, 2007, 2008a,b,c; Jørgensen and Kollman 2009; Thiele et al. 2010). In these systems *R. rugosa* threatens native dune vegetation and leads to decreased native species diversity. These studies demonstrate that *R. rugosa* is a significant problem in conservation of dune habitat (e.g., Isermann 2008c). The invasion of *R. rugosa* on sand dunes was facilitated in European coastal areas by planting for sand stabilization and coastal protection (Isermann 2008c)

Rosa rugosa is widely distributed in Nova Scotia, from Yarmouth in the southwest to northern Cape Breton Island (Roland and Smith 1969; Roland 1998). The species can be expected on roadsides and rocky beaches in many coastal areas of Nova Scotia where it often co-occurs with the native *R. virginiana* Mill. (Hill and Garbary, unpublished observations). Despite its widespread distribution and local abundance, there have been no previous reports of *R. rugosa* invading coastal dunes and impacting populations of native plant species. Recently, Hill and Blaney (2009) suggested that *R. rugosa* was one of ten non-native species in Nova Scotia likely to become invasive. Here, we document for the first time *R. rugosa* as a significant invader of sand dune habitats in North America. We also show that *R. rugosa* can modify communities of native species in sand dune systems on western Cape Breton Island and the northern mainland of Nova Scotia.

Methods

1. Surveys

A survey of 24 sand dunes comprising coastal beach habitats in the southern Gulf of St. Lawrence was conducted for *Rosa rugosa* in May and June 2010 (Table 1, Figure 1). The Cape Breton sites were resurveyed in mid July to document flower colour (pink or white). All sites were in Nova Scotia and ranged from Cheticamp in the northeast to Fox Harbour in the northwest. A walking survey was conducted at each beach by one to three individuals for 15 min to 8 h to determine the distribution, number and extent of colonies of *R. rugosa*. Beach area was determined using aerial photographs (1:12 500), Google Earth, and locations at the start and end of beach surveys as determined using a GPS unit (Model eTex Summit, Garmin, Olathe, Kansas). At Cheticamp, Belle Cote, Margaree Harbour, Inverness and Port Hood, where communities were adjacent to the beach habitat, a driving survey was conducted to look for plantings of *R. rugosa*. In locations where a colony was observed in the communities, the geographic coordinates were recorded along with extent of the colony. This included an approximation of the length, diameter and height of the *R. rugosa* stand. In more natural habitats the maximum length and diameter of the colony was measured with a 30 m measuring tape, and then the

TABLE 1. General features of dune systems examined for *Rosa rugosa*. Note: all dunes are subject to coastal erosion as a consequence of sea level rise. Scale for extent of colonization: 0) absent; 1) with significant populations adjacent to beach system, but not yet colonizing beach itself; 2) a few small clones none of which achieve 100% cover; 3) as in 1 but with some larger colonies; 4) >5 independent colonies on beach with some having extensive area and cover; 5) as in 3, but with a significant area of the beach colonized.

Dune	Coordinates (UTM – 20T)	Dune size (km)	Dune stresses	Extent of colonization	Presence of *R. rugosa* in adjacent communities
Cape Breton Island					
Cheticamp north #1	5170064 N 0655237 E	0.03 × 0.57		3	+
Cheticamp, north #2	5168939 N 0654156 E	0.04 × 0.08		3	+
Cheticamp Beach	5162856 N 0650506 E	0.50 × 0.05	rock wall, vehicle traffic	5	+
Belle Cote	5145306 N 0645424 E	0.50 × 0.06	rock wall, vehicle traffic	5	+
Margaree Harbour	5144667 N 0644904 E	0.33 × 0.05	trails	5	+
MacKays Cape	5142936 N 0642938 E	0.18 × 0.04		0	–
Chimney Corner	5139052 N 0640937 E	0.25 × 0.05		0	–
Inverness	5121212 N 0629832 E	0.45 × 0.05	boardwalk, extensive trails	2	+
Mabou	5104031 N 0617496 E	0.90 × 0.13		4	+
Port Hood	5097392 N 0613175 E	0.34 × 0.03		1	+
Port Hood Station	5095427 N 0613678 E	0.64 × 0.03	boardwalk	1	+
Little Judique	5090940 N 0614197 E	0.03 × 0.32		2	–
Judique Central	5082546 N 0616726 E	0.05 × 1.10		2	–
Mainland Nova Scotia					
Tracadie	5055553 N 0604817 E	0.05 × 0.5	road, highly eroded, extensive gravel	0	–
Bayfield	5053910 N 0598203 E	0.04 × 0.1	highly eroded, extensive gravel	0	–
Pomquet	5055833 N 0592391 E	0.14 × 0.78	boardwalk, trails, poison ivy	0	–
Monks Head	5068870 N 0591879 E	0.05 × 0.68	ATV traffic	0	–
Captains Pond	5058897 N 0589655 E	0.05 × 0.76		0	–
Dunns Beach	5059528 N 0587941 E	0.05 × 1.68	ATV traffic, trails	0	–
Big Island	5059706 N 0628021 E	0.04 × 1.26	road, high foot traffic	0	–
Melmerby Beach	5055911 N 0538481 E	0.08 × 1.30	boardwalk, high foot traffic	2	–
Little Caribou Spit	5064475 N 0526795 E	0.05 × 0.83		0	–
Waterside Provincial Park	5067515 N 0517175 E	0.13 × 0.81	boardwalks	5	–
Fox Harbour	5076108 N 0466639 E	0.02 × 0.33	highly eroded	0	

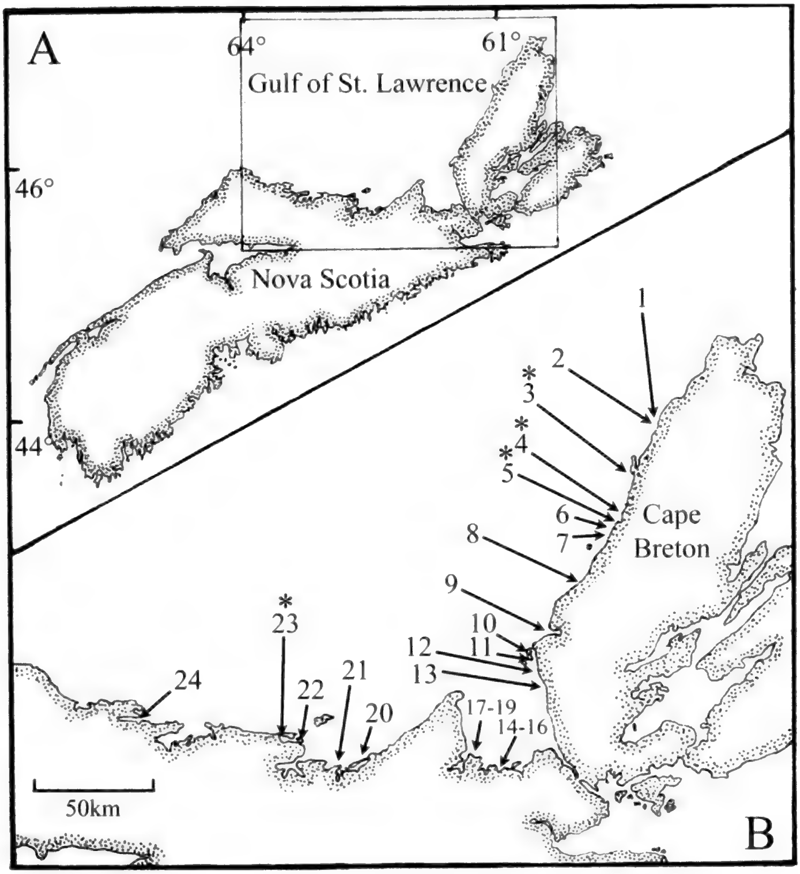


FIGURE 1. Map of Nova Scotia (A) with insert of enlarged map of the coast of Nova Scotia along the Gulf of St. Lawrence (B) with survey results for *Rosa rugosa*. Key: Long arrows, sites with *R. rugosa* on sand dunes; short arrows, sites with no *R. rugosa*; asterisks, sites with major beach colonization. Sites: (1) Cheticamp north #1; (2) Cheticamp north #2; (3) Cheticamp Beach; (4) Belle Cote; (5) Margaree Harbour; (6) MacKays Cape; (7) Chimney Corner; (8) Inverness; (9) West Mabou; (10) Port Hood; (11) Port Hood Station; (12) Little Judique; (13) Judique Central; (14) Tracadie; (15) Bayfield; (16) Pomquet; (17) Monks Head; (18) Captains Pond; (19) Dunns Beach; (20) Big Island; (21) Melmerby Beach; (22) Little Caribou Spit; (23) Waterside Provincial Park; (24) Fox Harbour (see Table 2 for site details.)

maximum height in the colony was measured using a meter stick or measuring tape. Cover of the overall area was estimated. The occurrence of native sand dune species, in particular *Ammophila breviligulata* Fern., *Lathyrus maritimus* (L.) Bigelow, *Myrica pensylvanica* Mirbel, and *R. virginiana* Mill., were noted.

2. Distinguishing *Rosa rugosa* and *R. virginiana*

Rosa rugosa is easily distinguished from the native, extremely common, *R. virginiana* based on features of leaves, stems and fruits. Thus leaves are larger in *R. rugosa* and the stems much coarser and more densely thorny. In *R. rugosa* the new stems are green and then turn grey with age; *R. virginiana* has characteristic red bark. The mature fruits of *R. rugosa* are often very large (i.e., plum-sized), bright orange-red and have very long sepals. This contrasts with *R. virginiana* with raspberry-sized, dark-red fruits with relatively short sepals. See Roland (1998) for additional features and a key to all *Rosa* species in the province.

Results

1. Herbarium survey

Herbarium records in the Nova Scotia Agricultural College (NSAC; abbreviations from Thiers, Index Herbariorum) and Acadia University (ACAD) show *R. rugosa* to be widely distributed in Nova Scotia. This hardy perennial has been recorded in 10 counties of the province in both inland and coastal locations as well as on Sable Island. Records in ACAD have spec-

imens from dune systems as early as 1953. Casual observations in Digby and Guysborough Counties show *R. rugosa* to be widespread in many seaside locations (DJG, personal observations). Based on these records and our observations (below) *R. rugosa* might be expected on diverse coastal habitats throughout the province.

2. Overview of colony characteristics

Over 100 colonies of *R. rugosa* occurred at 11 sand dune, barrier beach systems. These were mostly in Cape Breton, and only two beaches on the mainland (Melmerby and Waterside, Table 1, Figure 1) had colonies of *R. rugosa*. These colonies ranged from a single small shoot with an area of 25 cm^2 to extensive colonies with hundreds of shoots with areas up to 315 m^2. Area was skewed towards smaller colonies with mean area of 36.7 ± 60.4 m^2 (mean ± s.d.), and few colonies over 100 m^2 (Figure 2). These colonies had a great range in cover from ca. 10% to over 90% (mean 44.5 ± 24.8%). Similarly, maximum height of colonies varied from 10 to 250 cm (mean 80.6 ± 47.2 cm). There was a poor relationship between maximum colony height and colony area (r^2 = 0.19, Figure 2). Thus, while virtually all colonies less than 10 m^2 had a maximum height of 1 m or less, many large (i.e., > 10 m^2) colonies also had maximum heights < 1 m. Indeed, the three colonies with the largest areas (all at West Mabou) had maximum heights of 30-50 cm, which differed greatly from all other large colonies.

The resurveyed sites in July from Cape Breton generally had a mixture of both pink and white flowers. About 20% of the individual colonies had white flowers. Cheticamp Beach was the only site with numerous colonies where flowers were exclusively pink.

3. Heavily colonized sites

Of those beaches where it was present, four (Cheticamp, Belle Cote, Margaree Harbour and Waterside, Table 2) were heavily colonized with 12 – 42 colonies covering 404 – 2651 m^2 with maximum heights of 1.5 – > 2 m and with central cores in which there was 100% cover. Total beach cover was estimated at 0.4 – 8.8% of beach area surveyed. These established colonies often had hundreds of shoots and a ground cover of bare sand or leaf litter derived from *R. rugosa*. The Belle Cote site had colonies in which large basal rosettes of *Sonchus arvensis* L. were present. The margin of these colonies had typical sand dune vegetation of *Ammophila breviligulata, Myrica pensylvanica* and *Lathyrus maritimus*. *Rosa virginiana* was a common member of this assemblage, although when it occurred adjacent to *R. rugosa*, it was typically of much smaller stature. The margins of some larger clones were well defined; however, for many there was a diffuse zone of smaller shoots ca. 0.5 m, suggesting active colonization of the surrounding dune community. These sites typically had many smaller, more diffuse colonies extending over 0.5 – 10 m^2 with cover of 10-30%. There was often a conspicuous linear sequence of progressively smaller shoots connected by rhizomes at 5 – 10 m from the core of the colony.

Three of these sites (all but Waterside) had extensive populations of *R. rugosa* ca. 100-300 m distant in the human communities immediately adjacent to the dunes. At Cheticamp and adjacent villages we observed 34 separate plantings in the form of hedges and individual clumps scattered throughout the community. Some of these were escapes from cultivation and were established on roadside or between the main road and the seashore. The two dune systems at the mouth of Margaree Harbour had the largest colonies of *R. rugosa* in the surrounding villages. Indeed, the road through the village of Margaree Harbour had an almost continuous population of *R. rugosa* in which one colony alone formed a continuous hillside patch estimated at over 1000 m^2.

4. *Rosa rugosa* at other sites

The remaining seven sand dune systems with *R. rugosa* had greatly reduced incidences of colonization. These ranged from 1 – 5 colonies in which the *R. rugosa* comprised 0.25 – 640 m^2. While the area occupied by *R. rugosa* at West Mabou was considerably greater than at Margaree Harbour (ca. 663 vs 400 m^2 respectively), the percent of the beach occupied was several orders of magnitude less at West Mabou.

The two beaches north of Cheticamp proper (sites 1-2) had limited colonization with only 2-5 colonies and a cover of *R. rugosa* of 5 – 98 m^2. These colonies were scattered over the beach system from just behind the dune crest in *A. breviligulata* to areas adjacent to *M. pensylvanica* and *R. virginiana*.

The largest dune system examined in Cape Breton was at West Mabou. The dune front is about 10 m above the beach and there are at least three parallel dunes that merge 200 – 400 m shoreward into freshwater ponds, boreal forest or Mabou Harbour at rear. This apparently pristine system hosts Piping Plovers (*Charadrius melodus*, one was observed during our survey) and had dense populations of *A. breviligulata*, *M. pensylvanica* and *L. maritimus* and assorted forbs. Four independent colonies of *Rosa rugosa* were observed. Three of these were extensive, covering at least 150 m^2. They differed from colonies at other sites by having a max height of 30 – 50 cm. They had very low cover (< 20%), extensive bare sand and a diverse population of non-native forbs among the colonies. Given the low stature of the shoots and the large size of the dune system (Table 1), it is possible that other populations of *R. rugosa* may have been missed.

Port Hood (site 10) has an extensive sand dune system in which the dunes comprise two parallel dunes about 3 m high. A half hour inspection north of the beach parking lot did not reveal any *R. rugosa* on the

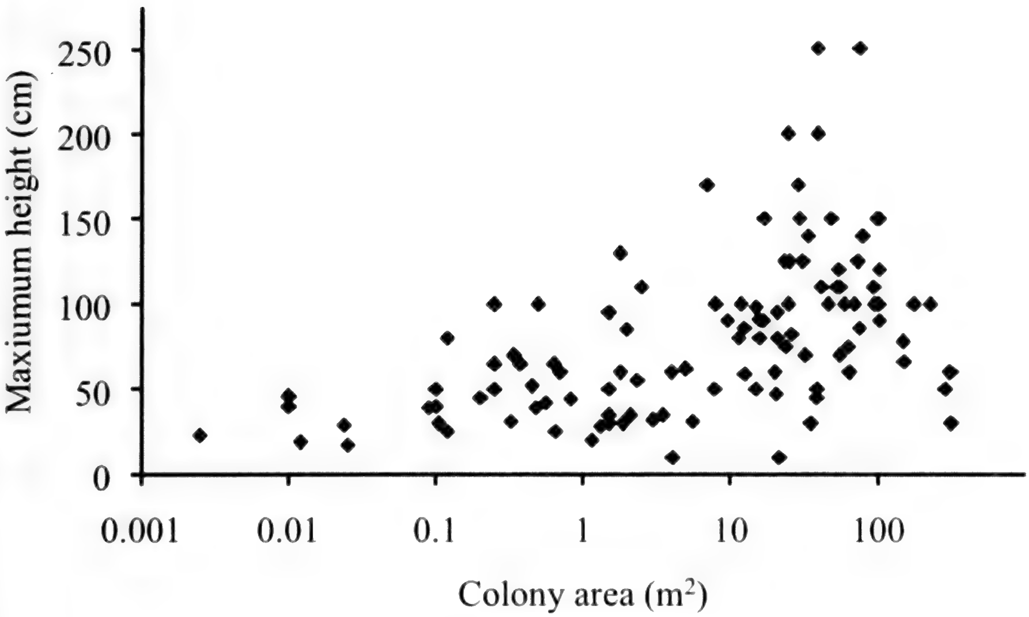


FIGURE 2. Scatter plot showing colony area and maximum height of *R. rugosa* colonies on sand beach systems in Nova Scotia.

dunes. However, three clumps at least 3 m in diameter and a maximum of 2.5 m tall grew adjacent to the parking lot. Two of these colonies had numerous small individuals within a meter of the core suggesting that active expansion was occurring. Even slight expansion of these colonies would colonize the sand dunes. The village of Port Hood had numerous plantings as individual beds or hedges; indeed, along 0.5 km of the main street we counted nine plantings in beds and hedges with plants at almost every other dwelling.

The day park at Port Hood Station (site 11) had 14 small, planted beds of *R. rugosa* in which the clumps were a maximum of 50 cm high and 1 m in extent. These occurred in a grassy area surrounded by a parking lot. The invasive properties of *R. rugosa* were demonstrated in that numerous new shoots up to 10 cm tall were arising within one meter of the edge of the original colony (in one case 45 shoots were counted in the surrounding grass plot). An inspection of ca. 1 km of dune along the boardwalk did not reveal any *R. rugosa*.

At two sites (Melmerby and Inverness) there were only two clumps, and these were adjacent to boardwalks through the beaches. These colonies were relatively small with maximum cover of 6 m^2.

Discussion

At three of the four most affected sites (all but Waterside) there was an apparent relationship between extensive artificial plantings of *R. rugosa* and the colonization of nearby sand dunes. These, often-extensive plantings provide a continuous source of propagules in the form of mature fruits that can colonize nearby beaches via roadsides. These, in turn, provide a potential conduit for invasion of sand dunes. Our observations are consistent with those of Jørgensen and Kollmann (2009) who demonstrated that dune invasion by *R. rugosa* was associated with roads, tracks and houses. Marine dispersed fruit was considered for an introduction to Norway (Fremstad 1997), and this might account for introductions to Nova Scotia dunes well away from roads or habitation. *R. rugosa* is known to be dispersed by birds (Bruun 2005; Rajakaruna et al. 2009), and this would explain the apparent random occurrences on dune systems such as at Judique Central.

Rosa rugosa is extremely tolerant of seemingly adverse environmental conditions. In its native and artificial habitats, *R. rugosa* is extremely drought tolerant, salt tolerant, fire tolerant, and tolerant to destruction of above ground tissue, and sand covering (Belcher 1977; Dirr 1978; Augé et al. 1990; Didriksen 1999; Tsuda et al. 1999; Bruun 2005). Symptomatic of this tolerance was the occurrence of colonies in Cheticamp just above the high tide mark and along roadsides to the plow line. Even excavation of the clone may be ineffective as a method of control as root/rhizome fragments may regenerate (Bruun 2005). Weidema (2006) describes a variety of control measures including excavation, herbicides or repeated cutting.

Two strategies of clonal expansion have been reported for *R. rugosa* (Bruun 2005). Thus colonal extension

TABLE 2. Colonization of the four most impacted dunes with *Rosa rugosa*.

	Number of colonies	Area of *Rosa rugosa* (m^2)	Beach area (m^2)	Dune cover with *Rosa rugosa*
Cheticamp	42	1,030	25,000	4.1%
Belle Cote	32	2,651	30,000	8.8%
Margaree Harbour	12	404	7000	5.7%
Waterside	21	434	105,300	0.4%

is typically by phalanx, but in herbaceous communities a guerrilla strategy can prevail (Bruun 2005). The latter was most commonly observed on the *A. beviligulata* dominated dunes we studied, with 2-4 shoots developing more-or-less in a line from the parent clone. Since most of our observations were done in May prior to the flush of new shoots (ca. one month after bud break, Bruun 2005), we only observed occasional new shoots, ca. 5 cm in height.

While there is debate in Europe whether *R. rugosa* is having a fundamentally negative impact on colonized dunes (Bruun 2005), our observations on at least four Nova Scotia dune systems (Cheticamp, Belle Cote, Margaree Harbour, Waterside) suggest this is the case. Within its impenetrable colonies, native species are largely excluded and a thin litter layer forms of fallen leaves, or a bare sand surface occurs. These monospecific stands probably exclude the sand-trapping *A. breviligulata* (description of rhizome network in Eyre, 1968 for *A. arenaria*) as well as its nitrogen-fixing associates, *L. japonicus* and *M. pensylvanica*. Without inputs of fixed nitrogen, the introduced rose will depend upon nitrogen mineralized from its own litter and as erosion removes organic materials, dense clones of *Rosa rugosa* may become moribund as fertility decreases. Although there are advocates for the planting of this rose to control erosion, logic indicates that the introduction of such a dominant could destabilize dunes in the long-term. It is known that grass and nitrogen-fixing associations can bring stability to low fertility ecosystems through an alternation of dominance that depends upon levels of soil nitrogen. In long-term pastures, a stable system of alternation between dominants is described as grass (*Lolium perenne*), takes over at elevated soil nitrogen levels, but is in turn invaded by nitrogen-fixing legumes (*Trifolium repens*) when soil nitrogen levels decline (Turkington and Harper 1979). The associations on the beaches of Sable Island between the beach grass, *A. breviligulata* and the legume, *Lathyrus japonica*, appear to mirror the pasture-model as the nitrogen content of grass tissues is greater in grass:beach pea associations (D. G. Patriquin. personal communication, 8 June 2010). In addition to legume inputs, large nitrogen inputs are possible from bayberry (*Myrica pensylvanica*), whose nodule fixation rates are of the same order as that of legumes or alders (Morris et al. 1974). The bayberry is a key player in the nitrogen economy of dunes and it is particularly resistant to dune blow-outs (Morris et al. 1974). Despite the claims made of the structural qualities of the massive invasive, *R. rugosa,* its competitive exclusion of all the nitrogen-fixing associates in this beach community will lead to an unstable ecosystem in the long-term.

The status of *R. rugosa* elsewhere in Nova Scotia needs to be examined. For example, there are several specimens of *R. rugosa* in the E. C. Smith Herbarium (ACAD) from Sable Island. These specimens (#24139, #30865) were collected by John Erskine in 1953, and have the notations "spreading from hedge" and "surrounding garden near old Main Station". Since Sable Island has now been named a national park, managers should be concerned about the invasiveness of *R. rugosa* onto the sand dunes that characterize the island, and the impact of such an invasion on indigenous wildlife.

While sea level is a global phenomenon, the rate of the rise in Nova Scotia is exacerbated by a natural land subsidence that will result in an estimated effective change of at least 70 cm by the end of this century (Forbes et al. 2004). Effective sea level rise is already affecting fringing salt marshes in the southern Gulf of St. Lawrence (Garbary et al. 2008), and the erosion of coastal sand dunes is another manifestation of this phenomenon. If the current dune systems are to remain intact, management practices must reflect this reality. While local government authorities cannot mitigate sea level rise, management of *R. rugosa* on dune approaches may slow invasion. *R. rugosa* should be considered a noxious weed in coastal areas adjacent to sand dune systems and removed; it should certainly not be part of ornamental plantings in dune-side parking lots as we observed at Port Hood Station, a site managed by Nova Scotia Department of Natural Resources.

Rosa rugosa is one of a number of shrubs that have become naturalized in Nova Scotia; other examples include *Euonymus europea* L. (Garbary and Deveau 2008), *Cytisus scoparius* (L.) Link, *Rosa multiflora* Thunb., and *Rhamnus cathartica* L. (Hill and Blaney 2009). Of these species, *R. rugosa* is the only species known to invade dune systems. While we cannot demonstrate negative effects on native vegetation, most of the large clumps (i.e., clump area > 10 m^2) of *R. rugosa* are monospecific. Exotic rose stands occur in a surrounding matrix community that is co-dominated by the mat-forming beach grass and one to two nitrogen

fixing associates (viz. *L. maritimus* and *M. pensylvanica*) as well as native rose, *R. virginiana*.

While we have some evidence that *R. rugosa* colonizes dune systems along road corridors from human habitation (e.g., Cheticamp and Margaree Harbours), it is also possible that fecal material from birds feeding on the hips provides an initial seed bank. Accordingly, Rajakaruna et al. (1998) found *R. rugosa* on guano soils on a remote bird-nesting island in the Gulf of Maine. This seems likely for the West Mabou dunes where large patches of *R. rugosa* were only found near the far end of the dune system that is relatively isolated from residential communities. Smith and Schofield (1959) did not find *R. rugosa* on two bird islands off the east coast of Cape Breton; however, their field work in 1954 may have predated the establishment of *R. rugosa* populations on the adjacent mainland which is sparsely settled.

While *Rosa rugosa* has been planted as an ornamental in Nova Scotia for at least 50 years, but the timing of the onset of colonization of sand dune systems and the development of invasive tendencies remain unknown. It is unclear whether the already erosion-stressed beaches and climate change are providing synergistic effects that are increasing *R. rugosa*'s invasiveness, or if we are only now recognizing a relative stable-state that has been present over a longer period. Also unknown are whether the occurrence of *R. rugosa* on regional sand dunes represents a stabilizing influence in terms of sand movement. The answers to these questions require longer term monitoring of dune systems where various degrees of colonization have occurred. Nevertheless, the evident ability of this species to monopolize dunes and competitively exclude the native plant community presents a potential threat to biodiversity and ecosystem function that should not be overlooked.

Acknowledgments

We thank Gretchen Noyes-Hull and the Gulf Aquarium and Marine Science Centre for hosting our stay in Cheticamp, M. Isermann for providing literature and comments on a draft of the ms, M. Garbary for helpful comments on the ms and Art Lynds (Nova Scotia Department of Natural Resources) for helpful, contextual discussion. This work was supported by grants from the University Council for Research for St. Francis Xavier University and NSERC Discovery Grants to DJG.

Literature Cited

Augé, R. M., A. J. W. Stodola, and **D. M. Gealy.** 1990. Turgor maintenance in *Rosa rugosa* grown at three levels on nitrogen and subjected to drought. Journal of Environmental Horticulture 8: 108-112.

Belcher, C. R. 1977. Effect of sand cover on survival and vigor of *Rosa rugosa* Thunb. International Journal of Biometerology 21: 276-280.

Bruun, H. H. 2005. Biological flora of the British Isles. *Rosa rugosa* Thunb. Ex. Murray. Journal of Ecology 93: 441-470.

Dassonville, N., S. Vanderhoeven, V. Vanparys, M. Hayez, W. Gruber, and **P. Meerts.** 2008. Impacts of alien invasive plants on soil nutrients are correlated with initial site conditions in NW Europe. Oecologia 157: 131-140.

Davis, D. S., and **S. Browne.** 1996. The Natural History of Nova Scotia. Volume One, Topics and Habitats. Nimbus and Nova Scotia Museum, Halifax, Nova Scotia.

Didriksen, R. 1999. Hip rose – a problem in coastal habitats. Skoven 31: 237-239. [in Danish]

Dirr, M. A. 1978. Tolerance of seven woody ornamentals to soil-applied sodium chloride. Journal of Arboriculture 4: 162-165.

Eyre, S. R. 1968. Vegetation and soils: a world picture. Aldine Publishing Company, Chicago, Illinois.

Forbes, D. L., G. L. Parkes, G. K. Manson, and **L. A. Ketch.** 2004. Storms and shoreline retreat in the southern Gulf of St. Lawrence. Marine Geology 210: 169-204.

Fremstad, E. 1997. Alien plants in Norway. Japanese Rose – *Rosa rugosa*. Blyttia 55: 115-121 [in Norwegian].

Garbary, D. J., and **A. E. Deveau.** 2007. The Spindle Tree: *Euonymus europaea* L. (Celastraceae): a newly naturalized shrub in Nova Scotia. Canadian Field Naturalist 121: 85-88.

Garbary, D. J., A. J. Miller, R. Scrosati, K-Y. Kim, and **W. B. Schofield.** 2008. Distribution and salinity tolerance of intertidal mosses from Nova Scotian salt marshes. Bryologist 111: 282-291.

Hill, N. M., and **C. S. Blaney.** 2009. Exotic and invasive vascular plants of the Atlantic Maritime Ecozone. Pages 1-18 *in* Assessment of species diversity in the Atlantic Maritime Ecozone. *Edited by* D. F. McAlpine and I. M. Smith. NRC Research Press, Ottawa.

Isermann, M. 2007. Impact of *Rosa rugosa* on dune ecosystems at the German North Sea coast – in comparison with *Hippophaë rhamnoides*. Pages 23-28 *in* Rynket rose (*Rosa rugosa*) I Danmark. *Edited by* I. Weidema, H. P. Ravn and P. Vestergaard P. Biologisk Institut, Københavns Universitet, Forskningscenter for Skov- og Landskab samt Skov- og Naturstyrelsen, København, Denmark.

Isermann, M. 2008a. Expansion of *Rosa rugosa* and *Hippophaë rhamnoides* in coastal grey dunes: effects at different spatial scales. Flora 203: 273-280.

Isermann, M. 2008b. Classification and habitat characteristics of plant communities invaded by the non-native *Rosa rugosa* Thunb. in NW Europe. Phytocoenologia 38: 133-150.

Isermann, M. 2008c. Effects of *Rosa rugosa* invasion in different coastal dune vegetation types. Pages 289-306 *in* Plant Invasions: Human perception, ecological impacts and management. *Edited by* J. H. Brock, G. Brundu, L. Child, C. C. Daehler and P. Pysek. Backhuys Publishers, Leiden, The Netherlands.

Jørgensen, R. H., and **J. Kollmann.** 2009. Invasion of coastal dunes by the alien shrub *Rosa rugosa* is associated with roads, tracks and houses. Flora 204: 289-297.

Kollmann, J., L. Frederiksen, P. Vestergaard, and **H. H. Bruun.** 2007. Limiting factors for seedling emergence and establishment of the invasive non-native *Rosa rugosa* in a coastal dune system. Biological Invasions 9: 31-42.

Kollmann, J., R. H. Jorgensen, J. Roelsgaard, and **H. Skov-Petersen.** 2009. Establishment and clonal spread of the alien shrub *Rosa rugosa* in coastal dunes. A method for

reconstructing and predicting invasion patterns. Landscape and Urban Planning 93: 194-200.

Morris, M., D. E. Everleigh, S. C. Riggs, and **W. N. Tiffney.** 1974. Nitrogen fixation in bayberry (*Myrica pensylavanica*) and its role in coastal succession. American Journal of Botany 61: 867-870.

Rajakaruna, N, N. Pope, J. Perez-Orozco, and **T. B. Harris.** 2009. Ornithocoprophilous plants of Mount Desert Rock, a remote bird-nesting island in the Gulf of Maine, U.S.A. Rhodora 111: 417-447.

Roland, A. E. 1998. Roland's Flora of Nova Scotia, 3rd edition. Nimbus Publishing Ltd and Nova Scotia Museum, Halifax, Nova Scotia.

Roland, A. E., and **E. C. Smith.** 1969. The flora of Nova Scotia, Part II. The Dicotyledons. Proceedings of the Nova Scotian Institute of Science 26: 277-743.

Smith, E. C., and **W. B. Schofield.** 1959. Contributions to the flora of Nova Scotia VI. Notes on the vegetation of the Bird Islands. Canadian Field-Naturalist 73: 155-160.

Thiele, J., M. Isermann, A. Otte, and **J. Kollmann.** 2010. Competitive displacement or biotic resistance? Disentangling relationships between community diversity and invasion success of tall herbs and shrubs. Journal of Vegetation Science 21: 213-220.

Thiers, B. [continuously updated]. Index Herbariorum: A global directory of public herbaria and associated staff. New York Botanical Garden's Virtual Herbarium. http://sweetgum.nybg.org/ih/.

Tsuda, S., H. Fujita, and **K. Nishisaka.** 1999. Resprouting behavior of *Rosa rugosa* Thunb. after an experimental burning in Koshimizu Nature Reserve, Hokkaido, Japan. Actinia [Bulletin of the Manazuru Marine Laboratory, Yokohama National University] 12: 113-121. [in Japanese]

Turkington, R., and **J. L. Harper.** 1979. The growth, distribution and neighbour relationships of *Trifolium repens* in a permanent pasture: 1. Ordination, pattern and contact. Journal of Ecology 67: 201-218.

Ueda, Y., S. Nishihara, H. Tomita, and **Y. Oda.** 2000. Photosynthetic response of Japanese rose species *Rosa bracteata* and *Rosa rugosa* to temperature and light. Scientia Horticulture 84: 365-371.

Weidema, I. 2006. NOBANIS – Invasive Alien Species Fact Sheet – *Rosa rugosa*. – From: Online Database of the North European and Baltic Network on Invasive Alien Species – NOBANIS www.nobanis.org, Date of access 12/7/2010.

Received 12 July 2010
Accepted 31 August 2010

Development and Growth of Northern Leopard Frog, *Lithobates pipiens,* Tadpoles in North American Waterfowl Management Plan Permanent Basins and in Natural Wetlands

Daniel Pouliot and Jean-Jacques Frenette

Département de Chimie-Biologie, Université du Québec à Trois-Rivières, 3351 Boulevard des Forges, C.P. 500, Trois-Rivières, Québec G9A 5H7 Canada

Pouliot, Daniel, and Jean-Jacques Frenette. 2010. Development and growth of Northern Leopard Frog, *Lithobates pipiens,* tadpoles in North American Watefowl Management Plan permanent basins and in natural wetlands. Canadian Field-Naturalist 124(2): 159–168.

We monitored the development and growth of a cohort of Northern Leopard Frog (*Lithobates pipiens*) tadpoles, in one North American Waterfowl Management Plan (NAWMP) permanent basin and in one natural environment, a bay of the St. Lawrence River. We wanted to know if this kind of artificial wetland could be considered as suitable habitat for this declining species and compare the environment that was provided to the tadpoles to those found in natural conditions. We also measured metamorphs' snout-vent length at three different permanent basins and natural bays to verify if the results from the detailed monitoring could be generalized. Our results have showed that the tadpoles were able to complete their development in the permanent basin and that their growth was superior to those from the natural site. The metamorphs from the permanent basins were also, on average, longer than those from the natural sites. The NAWMP permanent basins are suitable for the Northern Leopard Frog and could be a useful tool in the conservation of this species.

Nous avons suivi le développement et la croissance d'une cohorte de têtards de Grenouille Léopard du Nord (*Lithobates pipiens*) dans un bassin permanent du Plan Nord Américain de Gestion de la Sauvagine (PNAGS) et dans un site naturel, une baie du fleuve Saint-Laurent. Nous voulions vérifier si ce type d'aménagement pouvait être considéré comme un habitat potentiel pour cette espèce en déclin et comparer les conditions environnementales disponibles pour les têtards. Nous avons aussi mesuré la longueur museau-cloaque des métamorphes provenant de trois bassins permanents et de trois baies du Saint-Laurent pour vérifier si les résultats obtenus par le suivi détaillé pouvaient être généralisés. Nos résultats ont montré que les têtards pouvaient compléter leur développement dans le bassin permanent et que leur croissance était aussi supérieure que dans le site naturel. Les métamorphes des trois bassins permanents étaient aussi, en moyenne, de taille supérieure à que ceux des sites naturels. Les bassins permanents du PNAGS peuvent être considérés comme des habitats potentiels pour la Grenouille Léopard du Nord. Ils pourraient représenter des outils utiles pour la conservation de cette espèce.

Key Words: Northern Leopard Frog, Grenouille léopard du Nord, *Lithobates pipiens*, tadpoles, têtards, North American Waterfowl Management Plan, Plan Nord Américain de Gestion de la Sauvagine, St. Lawrence River, Fleuve Saint-Laurent.

The North American Waterfowl Management Plan (NAWMP) was signed by Canada and the United States in 1986 in response to the major waterfowl decline observed throughout North America; Mexico joined the continental plan in 1994 (NAWMP Plan Committee 1998*). The main goal of the plan is to return duck and goose populations to their 1970s levels (NAWMP Plan Committee 2004*). Habitat losses and wetland degradation over the last decades have greatly contributed to waterfowl decline (Batt et al. 1989). Among the solutions used by the NAWMP partners to achieve their goal, has been the establishment of a network of managed and/or protected wetlands across Canada, the United States, and Mexico. NAWMP partners have aimed to diversify the types of wetlands available in response to the specific needs of waterfowl (*D.U.C. and NOVE Environnement inc. 1990). Some of the managed wetlands are temporary; for example, land is flooded in early spring so that it can support migrating waterfowl, after which it is drained for agriculture at the beginning of the summer (*Société de la Faune et Parcs Québec 2003). Other managed wetlands are permanent basins designed to provide waterfowl with sites for nesting and the raising of juveniles (D.U.C. and NOVE Environnement inc. 1990*).

Although NAWMP wetlands were developed for waterfowl, managers soon realized the potential of these managed areas for the conservation of other taxa. Managed wetland success stories have emphasized the quality of these wetlands for a diversity of birds (VanRees-Siewert and Dinsmore 1996; Locky et al. 2005) and for the growth of fish (e.g., Yellow-perch (*Perca flavescens*)) (Tardif et al. 2005). Schueler and Karstad (2000*) also note the abundance of the Northern Leopard Frog (*Lithobates pipiens*) in managed wetlands of the northern Ottawa River drainage in Ontario, Canada. They proposed that these wetlands may act as refuges or "source habitats" for this declining North American species in the Boreal Forest (Gibbs 1971; Wassersug 1976; Gilbert et al. 1994) and could contribute to the species survival at the local scale.

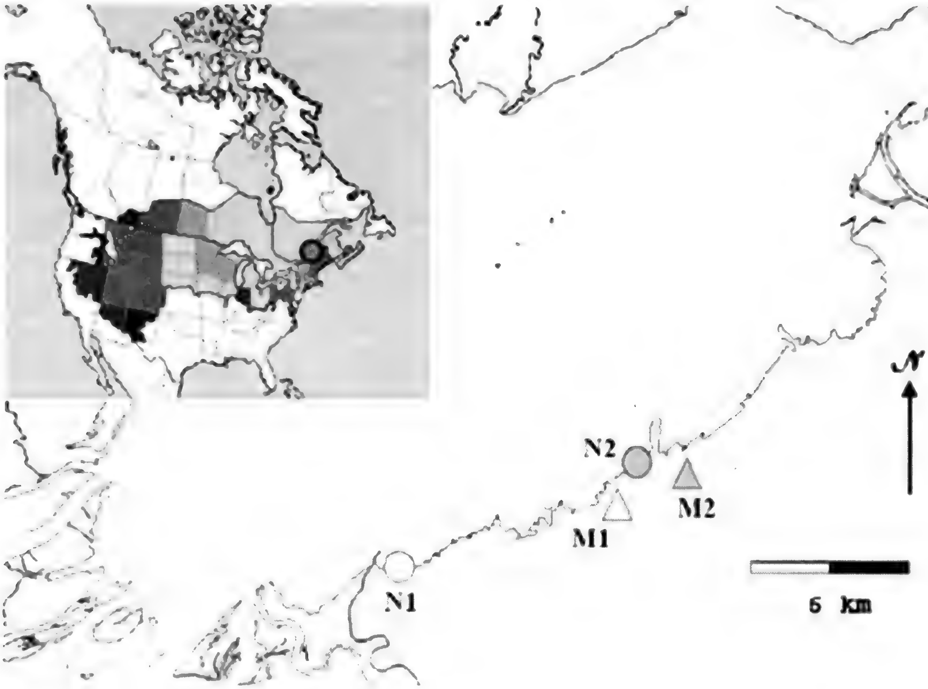


FIGURE 1. The circle on the top-left map shows the location of the study area. Northern Leopard Frog distribution is shown in tones of grey following the subnational "S" rank of NatureServe Conservation Status; the darker the tone the more endangered the species is (S5 to S1). The main image shows the locations of the study sites in Lac Saint-Pierre, St. Lawrence River, Canada: N1 and M1-Natural and Managed Monitoring Sites / N2, N3, M2 and M3-Natural and Managed metamorphosis sites.

The objective of the study reported here was to determine if the Northern Leopard Frog tadpole's were able to complete their development in one of these managed wetlands. We also wanted to compare it to the development and growth happening under natural environments and finally, explain the differences in tadpoles' development and growth by looking at the environmental conditions in their respective habitats.

Methods

Study sites

We conducted our research in Lac Saint-Pierre (46°12'N; 72°50'W), the largest fluvial lake (480 km^2) along the St. Lawrence River in Quebec, Canada (Figure 1). Lac Saint-Pierre is characterized by its large floodplain (180 km^2), which includes many natural and NAWMP-managed wetlands (Société de la Faune et Parcs Québec, 2003). The lake is shallow (mean depth of 3.17 m during the period of mean discharge) and covered with extensive macrophyte beds during most of the ice-free period.

Natural sites

The natural wetlands of Lac Saint-Pierre are colonized by plant communities that are sequentially drained from spring to summer. Water gradually uncovers first a Silver Maple (*Acer saccharinum*) forest, characterized by Reed Canarygrass (*Phalaris arundinacea*) in open areas, then, during the later stages, a low-depth marsh dominated by Common Spikerush (*Eleocharis palustris*) and various Bulrush species (*Schoenoplectus fluviatilis*, and *S. acutus*). Frogs lay their eggs in the flooded forest and tadpoles must follow the water mass, so their environmental conditions are dictated by the St. Lawrence River's water-level fluctuations.

North American Waterfowl Management Plan permanent basins

The NAWMP permanent managed wetlands in Lac Saint-Pierre are delimited by four dikes in a characteristic rectangular shape, a typical arrangement for this type of wetland (Figure 2). Water accumulates following snowmelt and spring rains. Water levels decrease gradually over the summer by evaporation and transpiration, but a pumping station can be activated to add water from the St. Lawrence River if the wetland becomes too dry. Drainage channels are present but the wetland is not usually flushed. The wetlands exhibit a depth gradient that allows for the establishment of mainly three aquatic plant communities: (1) the shallow water is dominated by an arborescent swamp of willow (*Salix* spp.) and/or Ash (*Fraxinus* spp.), with

FIGURE 2. The NAWMP permanent basin where tadpole' environment, development, and growth have been monitored. It exhibits the typical rectangular shape of a this artificial wetland design. Photo by André Michaud (Ducks Unlimited Canada). Used with permission.

dense aggregations of Cattail (*Typha angustifolia*); (2) the open marsh is densely colonized by common Spike-rush, an invasive flowering rush (*Butomus umbellatus*) at middle depths; and (3) open water is covered with submerged vegetation in the deepest areas. Northern Leopard Frog eggs are laid in both the arborescent swamp and the open marsh.

We characterized Northern Leopard Frog tadpole development, growth and immediate environment, at weekly intervals, in one natural site (N1) and in one NAWMP permanent basin (M1) during the 2004 season (Figure 1). These sites will henceforth be referred to as natural and managed monitoring sites. The monitoring began with the first observation of egg masses (14 May; designated week 1) and ended ten weeks later with the beginning of metamorphosis (13 July; designated week 10). We caught and measured metamorphs (Gosner stage 46) in our two monitoring sites (N1 and M1), as well as in four other sites (Figure 1), (further referred to as natural and managed metamorphosis sites). These four sites included two natural bays (N2 and N3), and two NAWMP permanent basins (M2 and M3). We also used SVL data from the same sites, both monitoring and metamorphosis, obtained by D. P., during previous works in 2003 and 2005.

Localization of Tadpole Habitat

Wetlands are highly heterogeneous ecosystems and tadpoles do not necessarily use all available areas. To ensure that we characterized the environmental conditions in areas only occupied by tadpoles, we first localized the tadpole habitats. To do so, we measured tadpole density with a dip net passed twice through the water column (following the bottom, horizontally, for about meter). The volume of water that passed through the net varied with water depth, from 0.08 to 0.13 m^3. We expressed tadpole density per unit of water volume (tadpoles/m^3).

In each of our two monitoring sites, every week, we measured tadpole density at 30 locations that were selected randomly and separated by a minimum of 20 meters. We considered representative tadpole habitat to be: the three locations in each of the natural and the managed wetlands with the highest density of Northern Leopard Frog tadpoles.

Environmental Conditions

In each of the three tadpole habitats, at both natural and managed monitoring sites, as selected weekly between 09h00 and 15h00, we measured the water depth using a meter stick (0.5 cm increments) and the surface water temperature with a thermometer (0.5°C

increments). We measured, *in situ*, photosynthetically active radiation (PAR) with a light meter (Li-COR μmoles/m^2/sec) and calculated the extinction coefficient (K_d PAR) following Wetzel and Likens (1991). We collected four liters of water in 2 L polypropylene containers. We pre-filtered the water samples on 63 μm Nitex (Filmar inc.) to eliminate large zooplankton and minimize grazing on the algae/protist community during the shipment of the water to the lab. Pre-filtered water samples were kept in a cooler with ice packs until arrival at the lab, where they were rapidly transferred to a dark room maintained at 4°C.

We used a 200 mL subsample to analyze for total nitrogen (TN) and total phosphorus (TP) according to standard methods in use in Yves Prairie's laboratory (GRIL). For sestonic chlorophyll *a* (Chl *a*) determination, we filtered water samples the same day on a duplicate GF/F filter (0.7 μm); extraction was by hot ethanol following Nusch (1980). Sestonic organic matter dry weight was measured according to Wetzel and Likens (1991). We used these variables to characterize the food availability in the water column. Chl *a* represents a measure of phytoplankton biomass. The sestonic organic matter dry weight includes living organisms and decaying matter such as feces, which are known to be beneficial for tadpole development and growth (Steinwascher 1978).

We used epiphytic periphyton attached to dominant macrophyte species as another index of food availability for tadpoles; at each tadpole representative habitat, we collected ten grams of submerged parts from the most representative macrophytes in a plastic bag containing 100 mL of distilled water. We agitated the bag for two minutes to thoroughly separate epiphytic periphyton from the macrophyte substrate. We then cleaned the macrophytes with a known volume of distilled water. The result of the washing-agitation process was a volume-known homogenate of distilled water and epiphytic algae/protists. We filtered this homogenate the same day on GF/F filter (0.7 μm) to evaluate the epiphytic Chl *a* biomass and epiphytic organic matter dry weight. We expressed epiphyte Chl *a* and organic matter availability per unit of plant area that we measured using an area-meter (AMC100 ADC Bioscientific LTD). Finally, to obtain a more realistic idea of the amount of available epiphytic food resources (Chl *a* and organic matter), we calculated the following epiphytic food availability index (EFA index) for each station:

EFA index = <u>μg Chl *a*/cm²</u> or <u>mg Organic matter /cm²</u> * Macrophyte % cover * Water depth

Tadpole Development and Growth

We monitored tadpole development and growth based on weekly captures in the six representative tadpole habitats, divided among the natural and managed monitoring wetlands. Our objective was to catch a minimum of 15 Northern leopard frog tadpoles per site/week but the final number between site and week is more variable. At first, tadpoles were identified by their uniformly black beak and later by the pattern of their back. Tadpoles were brought to the lab in a cooler with ice packs, euthanized using MS-222 and preserved in 10% neutral buffered formalin according to McDiarmid and Altig (1999). We determined developmental stage for all preserved tadpoles according to Gosner (1960). Tadpoles were individually, and briefly, placed on a dry towel to absorb excess fluid and weighed to the nearest 0.05 mg using a Sartorius balance (model CP225D).

Metamorphs

In 2004, during the week following the beginning of metamorphosis, we evaluated the length of the metamorphs (Gosner stages 46) at all six sites (monitoring N1 and M1 and metamorphosis N2, N3 and M2, M3). We caught metamorphs at the water-land interface, using a dipnet. We attempted to catch as many metamorphs as possible, during a period of approximately two hours per site. We measured the snout-vent length (SVL) with a caliper (Mitutoyo), marked every individual by cutting a single toe and releasing them on catch location.

Metamorphs SVL from previous years had been collected through the same methodology, at site M1, N1 and N2, in 2003 and 2005. We integrated this data to verify if the difference in the size at metamorphosis observed in 2004 was also present for other years.

Statistical Analyses

All statistical analyses were performed with SYSTAT 11. A discriminant function was obtained following a stepwise DFA (*F* to enter or reject 0.15) on the environmental variables. We used this analysis to identify variables or groups of variables that could best differentiate the characterized monitoring sites. Most variables were log or square root transformed to attain a normal distribution before DFA was performed. We used a two-tailed *t*-test to determine whether there was a significant difference ($\alpha = 0.05$) between the mean length of metamorphs from the natural and managed sites (N1, N2, N3 vs. M1, M2, M3).

Results

Environmental Conditions

Sestonic Chl *a*, maximum tadpole density, K_d PAR, and the ratio of TN:TP were entered into a discriminant function that correctly classified the natural and managed representative habitats in 74 to 79% of cases (Table 1). This discriminant function explained 46% of the total variance. Plotting of stations' discriminant function scores over time show that tadpole environments in the managed wetland were characterized by

TABLE 1. Results of the discriminant function analysis. The multivariate analysis indicates a significant difference between the two groups of Northern Leopard Frog tadpole habitats (Wilks' lambda = 0.684, Pillai Trace = 0.316, Lawley-Hotelling trace = 0.462; df= 4, *F*-ratio = 6.008, *P* = 0.0006); eigenvalue = 0.462.

Variables	Canonical discriminant functions	*F*-to-remove	Tolerance	CDF standardized by within variances
Constant	10.472	.	.	.
TN:TP	2.411	13.31	0.823	0.885
Sestonic Chl *a*	0.846	9.82	0.760	0.813
Tadpole density	–0.250	3.21	0.966	–0.436
K_d PAR	–0.381	0.93	0.873	–0.252
Classification matrix	**Natural**	**Managed**	**% Correct**	
Natural	23	7	77	
Managed	5	22	81	
Total	29	28	79	
Jackknifed	**Natural**	**Managed**	**% Correct**	
Natural	22	8	73	
Managed	7	20	74	
Total	28	29	74	

higher TN:TP ratios, higher sestonic Chl *a* availability, lower maximum tadpole density, and lower light extinction coefficients than the tadpoles from the natural monitoring site (Figure 3). Water depth, water temperature, sestonic organic matter, and periphytic food availability were not retained in the discriminant function, and are therefore considered to be relatively similar over time in both sites.

Development and Growth

Table 2 is showing the number of tadpoles caught, measured and weight, in each of the two monitoring sites in 2004. Figure 4 shows tadpole development (Gosner stage) at the two monitoring sites. The development generally followed the same pattern at both sites. However, from week 6 to 10 (15 June to 13 July), the variation in Gosner stages were greater in the natural wetland than the managed one, suggesting that a greater proportion of the tadpoles were not ready for emergence in the natural monitoring wetland compare to the more homogenous readiness in the managed monitoring site.

Because Gosner stages are highly correlated with time (Pearson correlation coefficient r_p = 0.941), wet weight of tadpoles were plotted against Gosner stages (Figure 5). This allowed comparison of individual tadpole weights for a given Gosner stage. Our results indicate similar growth patterns during the first three to four weeks in both monitoring sites. Afterward that time period, between weeks 5 and 9 (8 June to 8 July), tadpoles from the managed wetland grew more rapidly than those in the natural site (Figure 5).

The weight loss observed during week 9 (8 July) in the natural wetland and in week 10 (13 July) in the managed wetland, corresponds to the beginning of metamorphosis in each habitat (Gosner stage ≥ 42). At maximum mean wet weight, just before the beginning of metamorphosis, tadpoles from the managed wetland were more than three times as heavy as those from the natural wetland.

TABLE 2. Sample size (number of tadpoles caught, killed, staged and weighted) per week, in the two monitoring sites, in 2004.

Week	Date	Monitoring site	Sample size (tadpoles)
1	May 14	Natural	68
		Managed	41
2	May 18	Natural	90
		Managed	46
3	May 25	Natural	50
		Managed	32
4	June 02	Natural	41
		Managed	26
5	June 08	Natural	54
		Managed	24
6	June 15	Natural	40
		Managed	15
7	June 22	Natural	43
		Managed	7
8	June 29	Natural	56
		Managed	18
9	July 08	Natural	43
		Managed	12
10	July 13	Natural	44
		Managed	12
	TOTAL	Natural	529
		Managed	233

Metamorphs

Metamorphs from the managed monitoring site (Mean = 4.953 g (SD 0.882); Range = 3.0–7.5; *n* = 89) (Table 3) were significantly heavier (*P* < 0.001; *t* = 35.132; df = 188) than those from the natural moni-

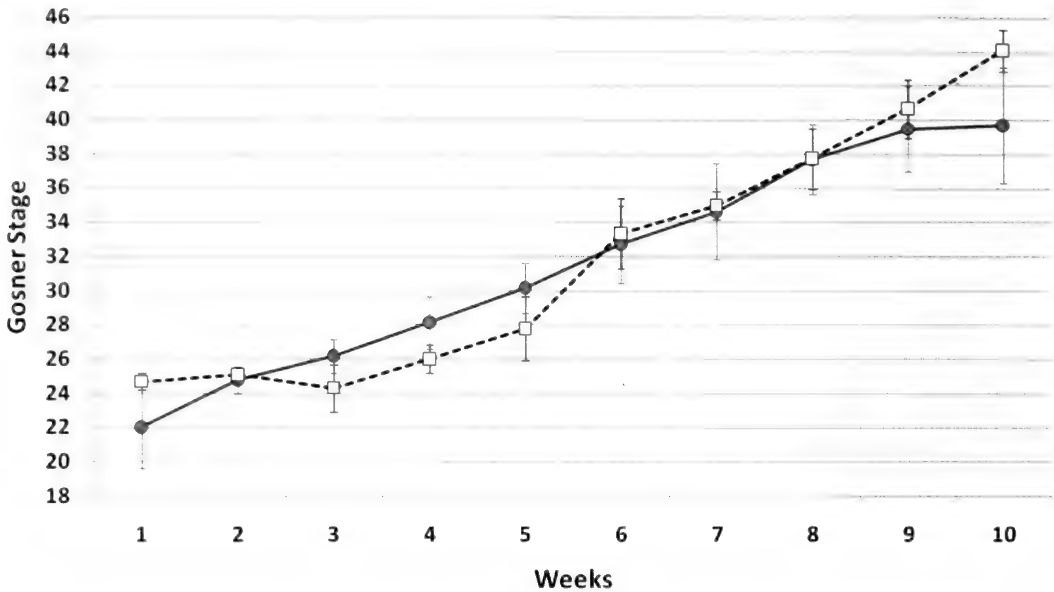


FIGURE 3. Weekly average (SD) tadpole Gosner stages, from week 1 to 10 (May 14th to July 13th 2004) , in the two monitoring sites: natural wetland (● and solid line) and the NAWMP permanent basin (□ and broken line).

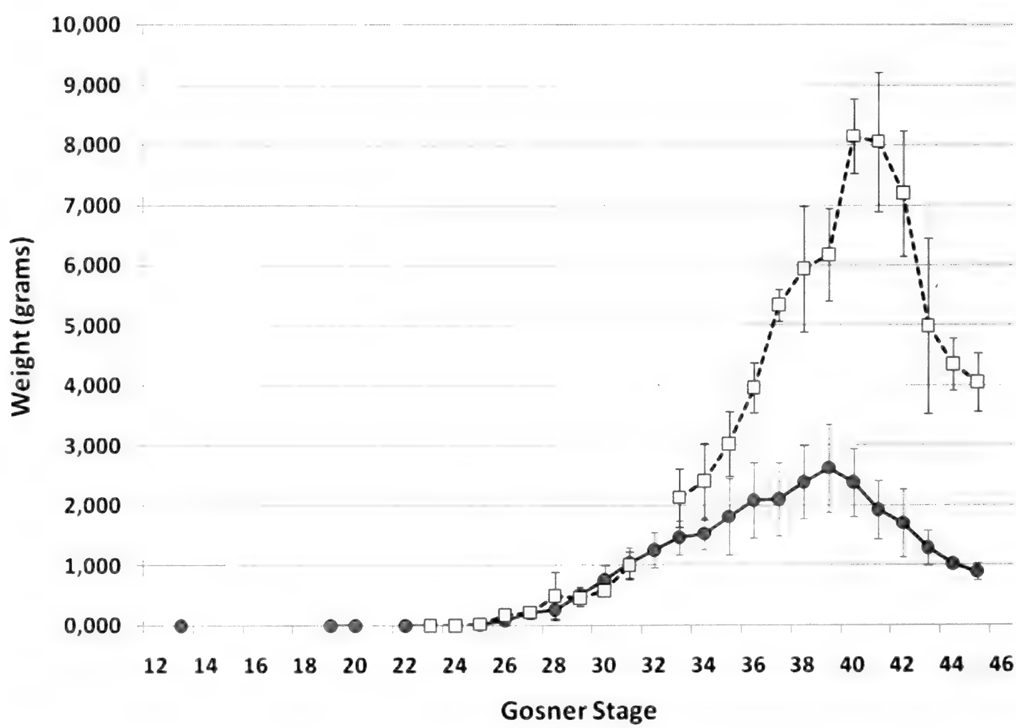


FIGURE 4. Average (SD) tadpole weight in grams, in function of the Gosner developmental stage, in the two monitoring sites: natural wetland (● and solid line) and the NAWMP permanent basin (□ and broken line).

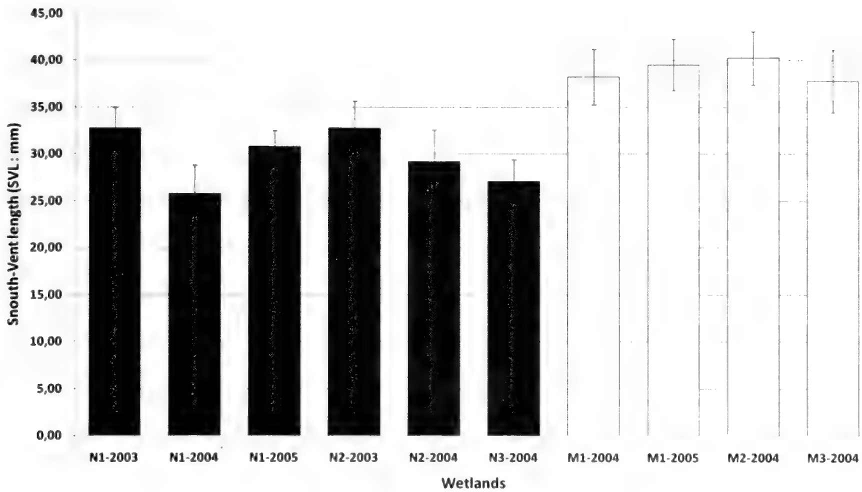


FIGURE 5. Snout-vent length of metamorphs from three natural bays (grey bars) and three permanent managed wetlands (white bars) on the south shore of Lac Saint-Pierre from 2003 to 2005. See Figure 1 for collection sites.

toring site (Mean = 1.471 g (SD 0.454); Range = 0.5–3.0; n = 106). The two-tailed t-test performed on the of metamorphs' SVL from the six metamorphosis sites, showed that metamorphs from the managed wetland were significantly longer ($P < 0.001$; $t = 26.995$; df = 398) than those from the natural wetland (Figure 6).

Discussion

NAWMP Permanent Basin as suitable habitat for Northern Leopard Frog tadpoles?

Our first objective was to determine if Northern Leopard Frog eggs laid in a NAWMP permanent basin could complete development. The monitoring of the development during the spring and summer 2004 in one of such basins, and the metamorphosis of froglets in mid-July 2004 in three different basins, strongly suggests that NAWMP permanent basins can be considered suitable habitat for Northern Leopard Frog tadpoles. Moreover, the previous observation of metamorphs in some of these basins in 2003 and 2005 supports the idea that the basins are not only sporadically suitable, but likely annually so.

In comparison to other NAWMP managed wetlands, the permanent basin presents the advantage that the minimum water level is maintained throughout the season. Such management practices eliminate the possibility of a lethal drying event. Such lethal events occur in other types of managed wetlands (Pouliot and Frenette, personal observation); temporarily flooded managed wetlands, designed as migratory stops for waterfowl, cannot support tadpoles up to metamorphosis since they are drained in early summer. Smaller artificial ponds connected to the St. Lawrence are sensitive to the variation of the river's water level and can dry out over the summer, or are used by warm water fish such as Brown Bullhead (*Ameiurus nebulosus*), Northern Pike (*Esox lucius*) and Smallmouth Bass (*Micropterus dolomieui*), all of which are potential predators for the tadpoles.

TABLE 3. Sample size (number of metamorphs caught, marked and snout-vent length measured, during the week following the observation of the first metamorphosis signs, in the six metamorphosis sites, in 2003, 2004 and 2005, depending on data availability.

Wetland	Year	Metamorphosis site	Sample size (metamorphs)
Natural	2003	N1	35
Natural	2004	N1	105
Natural	2005	N1	31
Natural	2003	N2	35
Natural	2004	N2	12
Natural	2004	N3	31
Managed	2004	M1	85
Managed	2005	M1	19
Managed	2004	M2	45
Managed	2004	M3	2

Tadpoles that developed in the NAWMP permanent basins grew more rapidly and emerged at a larger size than those from the natural sites. Size at metamorphosis is known to be important in amphibian life history (Wilbur and Collins 1973; Smith, 1987) as it affects individual survival (Altwegg and Reyer 2003) and the reproductive potential of adults (Smith 1987; Semlitsch et al. 1988). Considering the significance of

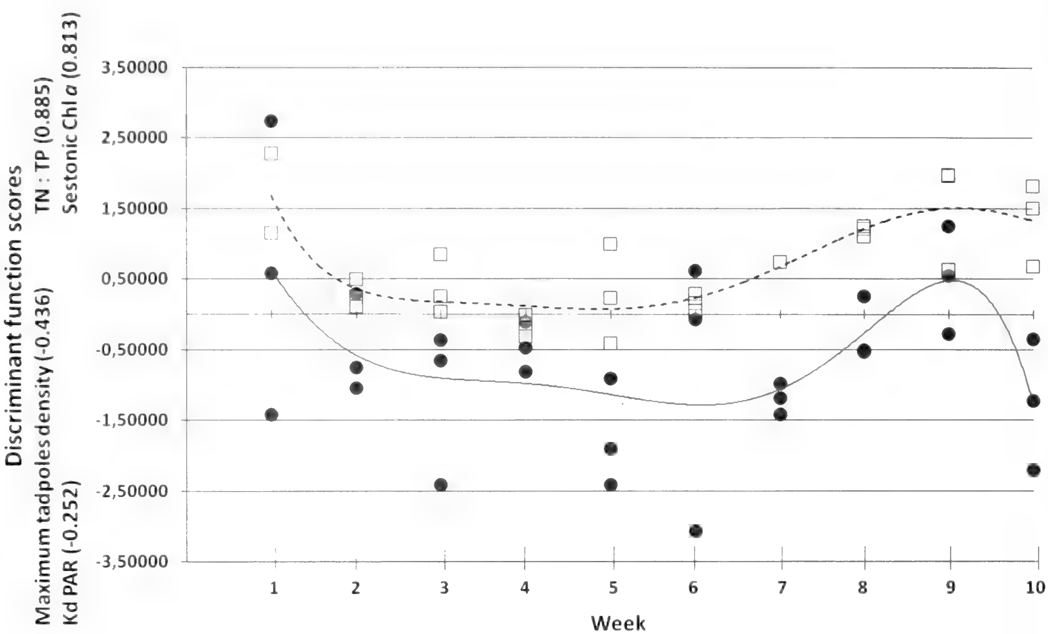


FIGURE 6. Weekly discriminant function scores, from May 14th to July 13th 2004, for tadpole habitat in the natural wetland (● and solid line) and the NAWMP permanent basin (□ and broken line). Polynomial curves used to show trend over the development period.

size at metamorphosis in amphibian life history, metamorphs produced by the permanent basins have equal, or maybe even higher chances to survive, than those produced by the natural wetlands. This emphasizes the capacity of NAWMP permanent basin to be a suitable habitat.

Considering that the Northern Leopard Frog tadpoles which evolved in the permanent basins completed their development and demonstrated a superior growth rate than those from the natural sites, the NAWMP permanent basins seem to be an interesting and promising tool for the local conservation of the Leopard Frog. The success of the different headstarting programs could potentially be increased by focusing the reintroduction efforts in areas where NAWMP permanent basins are present. By offering suitable development habitat, the permanent basins could lead to the establishment of self-sustaining populations. Further research should investigate whether the success story reported here is repeated in regions where the species is at risk, since different results could be expected in others regions.

Relationship between environmental conditions and tadpole development and growth

Our second objective was to describe and compare the environment of the tadpoles in our two wetlands to better understand the success or failure of the NAWMP permanent basin in supporting Northern Leopard Frog tadpoles throughout their development. The following variables: (1) TN:TP ratios; (2) K_d PAR coefficients; (3) sestonic Chl *a*; and (4) maximum tadpole density, were grouped together in a discriminant function that associated tadpole habitat stations to the correct wetland (natural or artificial) in 74–79% of cases. This function explained 46% of the total variance.

TN:TP ratio and K_d PAR are known to influence phytoplankton/periphyton community structure (Smith, 1986; Scheffer et al. 1997). The algae and protists that compose such communities—such as diatoms, dinoflagellates, chlorophytes, and cyanobacteria—are known to be of unequal food quality for tadpoles. Diatoms are generally considered high-quality food (Bold and Wynne 1985; Huggins et al. 2004) and cyanobacteria low-quality food (Brett and Muller-Navara 1997). Combined with a high K_d PAR coefficient (low light penetration), a low (< 29) TN:TP ratio favours cyanobacteria dominance in the phytoplanktonic community, with a consequent decrease in food quality for consumers (Smith 1986; Scheffer et al. 1997). Tadpoles raised in environments of higher quality food grow more quickly and metamorphose at greater size (Kupferberg 1997). Despite the fact that both wetlands had mean TN:TP ratios lower than 29, the ratios at the natural wetland were always lower than those at the managed site. Moreover, the natural wetland usually presented a higher light extinction coefficient, meaning that less light is penetrating the water column, favoring

the lower quality cyanobacteria over the better quality diatoms and chlorophytes. Considering these characteristics of the natural wetland, we suggest that the available food resources were of lower quality, which could have contributed to the differences in growth and size at metamorphosis. Further investigations should consider direct algae counts to establish phytoplankton/periphyton community structure and test this hypothesis.

Murray (1990) and Johnson (1991) observed that tadpoles that developed in food-rich environments grew more and metamorphosed at bigger sizes. It is also generally accepted that high tadpole density results in slower growth rates and smaller sizes at metamorphosis (Gromko et al. 1973; John and Fenster 1975; Wilbur 1977; Smith 1983). This has been explained by competition for available food resources (Wilbur 1977b; Berven and Chadra 1988; Murray 1990; Johnson 1991) and by higher frequencies of physical contacts between tadpoles, which is associated with reduced feeding time and growth (Gromko et al. 1973; John and Fenster 1975). Our results are consistent with these studies, since smaller sizes at metamorphosis were observed in the natural site, where lower quantities of food and higher maximal densities of tadpoles were observed.

Higher density also results in a greater range between lower and higher Gosner stages in a given cohort, since bigger tadpoles express competitive dominant behavior over smaller ones (Wilbur and Collins 1973). Our results suggest such competition due to higher densities. A larger range in Gosner stages was observed in the natural site, mainly when tadpole density was generally increasing, however this remained constant in the managed one.

Another potential explanation that may not have been captured by our monitoring is the aquatic connectivity of habitat areas. The higher the water level, the greater the connectivity; therefore the area of available habitat for aquatic organisms is also increased. In the context of high connectivity, tadpoles can disperse and forage in lower densities, feeding efficiently on available food resources. This scenario prevailed during the first weeks of development at both sites. It was essentially during this time, between weeks three and six that tadpoles at the natural site grew. When connectivity is low, available habitat becomes limited and tadpoles are forced to aggregate in remnant pools. This drastic change in tadpole habitat at the natural wetland is generated by the falling water level of the Saint-Lawrence River, concentrating tadpoles and their food in small pools (Figure 7).

These new environmental conditions should curtail tadpole growth for the reasons previously discussed. All these stressful conditions should favour the augmentation of development rate over growth in order to escape poor conditions. This ultimately results in smaller metamorphs, as proposed by Wilbur and Collins (1973).

FIGURE 7. Natural monitoring site on Week 9 (8 July 2004). During the summer, the water level decreases in the St. Lawrence River to the point that Northern Leopard Frog tadpoles are constrained to small pools, like the one shown here. Photo by Daniel Pouliot.

Again, in the theoretical perspective that the aquatic connectivity is the proxy for the Northern Leopard Frog development success and metamorphosis size, along the St. Lawrence and its floodplain, the local presence of the NAWMP permanent basins could definitively contribute to the maintenance of the species in the region. Since the St. Lawrence River water level has shown great inter-annual variation over the last decades (Hudon 1997), we could expect Northern Leopard Frog populations to also experience a great inter-annual variation in the recruitment rate in natural sites. On the other hand, the relatively stable water level conditions of the NAWMP permanent basins could be providing an annually equivalent flow of young Northern Leopard Froglets to the local populations.

Acknowledgments

We are grateful to J.-F. Lapierre, M. Lefebvre, D. Deshaies, and P. Lavallé for their able help with data collection. Thanks to J.-F. Desroches, F. W. Schueler, Marla Bojarski, and two anonymous reviewers, for their useful comments on the preliminary version of the text. Thanks to the Ministère des Ressources naturelles et de la faune du Québec for providing research permit (# 2004-06-21-028-17-SP). This research was funded by a) a grant from the Natural Sciences Research Council of Canada (NSERC) and the Fonds Québécois de la Recherche sur la Nature et les technologies (FQRNT) to J.-J. Frenette and b) a FQRNT postgraduate fellowship to D. Pouliot. This study is a contribution of the Groupe de Recherche Interuniversitaire en Limnologie (GRIL).

Documents Cited (marked * in text)

D.U.C. [Ducks Unlimited Canada], and NOVE environnement inc. 1990. Projet d'aménagement de la Commune de la Baie-du-Febvre. Étude d'impact sur l'environnement déposée au près du Ministère de l'Environnement du Québec. 134 pages.

NAWMP [North American Waterfowl Management Plan, Plan Committee]. 1998. North American Waterfowl Management Plan 1998. Strategic guidance: expanding the vision. Canadian Wildlife Service, U.S. Fish and Wildlife Service, Secretaria de Medio Ambiente y Recursos Naturales. 32 pages.

NAWMP [North American Waterfowl Management Plan, Plan Committee]. 2004. North American Waterfowl Management Plan 2004. Strategic guidance: strengthening the biological foundation. Canadian Wildlife Service, U.S. Fish and Wildlife Service, Secretaria de Medio Ambiente y Recursos Naturales. 22 pages.

Schueler, F. W., and **A. Karstad.** 2000. Northern Ontario Ducks Unlimited marshes: refugia for leopard frogs? Proceeding of the 5th Canadian amphibian and reptile conservation network annual meeting.

Société de la Faune et des Parcs du Québec. 2003. Le lac Saint-Pierre: Portrait des aménagements et autres sites d'intérêt faunique. Direction de l'aménagement de la faune Mauricie – Centre-du-Québec, Trois-Rivières, Canada. 176 pages.

Literature Cited

Altwegg, R., and **H. U. Reyer.** 2003. Patterns of natural selection on size at metamorphosis in water frogs. Evolution 57: 872-882.

Batt, B. D. J., M. G. Anderson, C. D. Anderson, and **F. D. Caswell.** 1989. The use of prairie potholes by North American ducks. Pages 204-227 *in* Northern Prairie Wetlands. *Edited by* A. G. Van Der Valk. Iowa State University Press, Ames, Iowa, USA.

Berven, K. A., and **B. G. Chadra.** 1988. The relationship among egg size, density and food level on larval development in the wood frog (*Rana sylvatica*). Oecologia 75: 67-72.

Bold, H. C., and **M. J. Wynne.** 1985. Introduction to the Algae: Structure and Reproduction, second edition. Prentice-Hall, Inc., Englewood Cliffs, New Jersey, USA.

Brett, M. T., and **D. C. Muller-Navara.** 1997. The role of essential fatty acids in aquatic food web processes. Freshwater Biology 38: 483-499.

Gibbs, E. L., G. W. Nace, and **M. B. Emmons.** 1971. The live frog is almost dead. Bioscience 21: 1027-1034.

Gilbert, M., R. Leclair Jr., and **R. Fortin.** 1994. Reproduction of the northern leopard frog (*Rana pipiens*) in floodplain habitat in the Richelieu River, P. Quebec, Canada. Journal of Herpetology 28: 465-470.

Gosner, K. L. 1960. A simplified table for staging anuran embryos and larvae with notes on identification. Herpetologica 16: 183-190.

Gromko, M. H., F. S. Mason, and **S. J. Smith-Gill.** 1973. Analysis of the crowding effect in *Rana pipiens* tadpoles. Journal of Experimental Zoology 186: 63-72.

Huggins, K., J.-J. Frenette, and **M. T. Arts.** 2004. Nutritional quality of biofilms with respect to light regime in Lake Saint-Pierre (Québec, Canada). Freshwater Biology 49: 945–959.

John, K. R., and **D. Fenster.** 1975. The effects of partitions on the growth rates of crowded *Rana pipiens* tadpoles. American Naturalist 93: 123-130.

Johnson, L. M. 1991. Growth and development of larval northern cricket frogs (*Acris crepitans*) in relation to phytoplankton abundance. Freshwater Biology 25: 51-59.

Hudon, C. 1997. Impact of water level fluctuations on St. Lawrence River aquatic vegetation. Canadian Journal of Fisheries and Aquatic Sciences 54: 2853-2865.

Kupferberg, S. 1997. The role of larval diet in anuran metamorphosis. Amercian Zoologist 37: 146-158.

Locky, D. A., J. C. Davies, and **B. G. Warner.** 2005. Effects of wetland creation on breeding season bird use in boreal eastern Ontario. Canadian Field-Naturalist 119: 64-75.

McDiarmid, R. W., and **R. Altig.** 1999. Research: Materials and Techniques. Pages 7-24 *in* Tadpoles, the Biology of Anuran Larvae. *Edited by* R. W. McDiarmid and R. Altig. University of Chicago Press, Chicago, Illinois, USA.

Murray, D. L. 1990. The effects of food and density on growth and metamorphosis in larval wood frogs (*Rana sylvatica*) from central Labrador. Canadian Journal of Zoology 68: 1221-1228.

Nusch, E. A. 1980. Comparison of different methods for chlorophyll and phaeopigment determination. Archiv *für* Hydrobiologie–Beiheft Ergebnisse der Limnologie 14: 14-36.

Sheffer, M., S. Rinaldi, A. Gragnani, L. R. Mur, and **E. H. Nes.** 1997. On the dominance of filamentous cyanobacteria in shallow, turbid lakes. Ecology 78: 272-282.

Semlitsch, R. D., D. E. Scott, and **J. H. K. Pechmann.** 1988. Time and size at metamorphosis related to adult fitness in *Ambystoma talpoideum*. Ecology 69: 184-192.

Smith, D. C. 1983. Factors controlling tadpole populations of the chorus frog (*Pseudacris triseriata*) on Isle Royale, Michigan. Ecology 64: 501-510.

Smith, D. C. 1987. Adult recruitment in chorus frogs: effects of size and date at metamorphosis. Ecology 68: 344-350.

Smith, V. H. 1986. Light and nutrient effects on the relative biomass of blue-green algae in lake phytoplankton. Canadian Journal of Fisheries and Aquatic Sciences 43: 148-153.

Steinwascher, K. 1978. The effect of coprophagy on the growth of *Rana catesbeiana* tadpoles. Copeia 1978: 130-134.

Tardif, D., H. Glémet, P. Brodeur, and **M. Mingelbier.** 2005. RNA/DNA ratio and total length of yellow perch (*Perca flavescens*) in managed and natural wetlands of a large fluvial lake. Canadian Journal of Fisheries and Aquatic Sciences 62: 2211-2218.

Vanrees-Siewert, K. L., and **J. J. Dinsmore.** 1996. Influence of wetland age on bird use of restored wetlands in Iowa. Wetlands 16: 577-582.

Wassersug, R. J. 1976. The identification of leopard frog tadpoles. Copeia 2: 413-414.

Wetzel, R. G., and **G. E. Likens.** 1991. Limnological Analyses, second edition. Springer-Verlag. New York, New York, USA.

Wilbur, H. M. 1977. Density-dependent aspects of growth and metamorphosis in *Bufo americanus*. Ecology 58: 196-200.

Wilbur, H. M. 1977b. Interactions of food level and population density in *Rana sylvatica*. Ecology 58: 206-209.

Wilbur, H. M., and **J. P. Collins.** 1973. Ecological aspects of amphibian metamorphosis. Science 182: 1305: 1314.

Received 12 February 2010
Accepted 23 July 2010

Successful Re-establishment of a Native Savannah Flora and Fauna on the Site of a Former Pine Plantation at Constance Bay, Ottawa, Ontario

P. M. CATLING AND B. KOSTIUK

Agriculture and Agri-Food Canada, Environmental Health, Biodiversity, Saunders Building, Central Experimental Farm, Ottawa, Ontario K1A 0C6 Canada; e-mail: catlingp@agr.gc.ca

Catling, P. M., and B. Kostiuk. 2010. Successful re-establishment of a native savannah flora and fauna on the site of a former pine plantation at Constance Bay, Ottawa, Ontario. Canadian Field-Naturalist 124(2): 169–178.

To determine the extent of successful restoration of native savanna vegetation at The Sandhills, an unusual and biodiversity-rich habitat in the Ottawa Valley, we gathered information from quadrats along transects so as to compare a restored clearing with the surrounding plantation. We provide an indication of success with respect to amount of effort and provide an example of some considerations and procedures for estimating success. With a minimum effort of tree cutting and bulldozing, removal of pine duff and litter, that is estimated to have required five people over a period of less than two weeks, a hectare was successfully restored to pre-settlement savannah vegetation. Apart from a limited seeding effort following the removal of planted trees, the re-establishment of native vegetation proceeded naturally, and it was likely aided by dispersal of seed from adjacent remnant vegetation along paths and firebreaks in the vicinity. Biodiversity, based on number of species and various indices, was substantially greater in the restored clearing than in the adjacent Red Pine platation. The semi-open Jack Pine plantation accommodated species of both shaded and open habitats and diversity approached that of the clearing. However, some species such as blueberry were in poor condition in the plantation, generally not producing flowers or fruit. In addition the non-dominant vegetation was much less of the cover. In the restored area there were more regionally rare species and much greater development of flowering herbaceous species and shrubs. Orthopteran insects, a useful indicator group of plant feeding species, had much higher diversity and abundance in the restored area. Savannah and natural sand barren that have been largely destroyed by plantation forestry can be restored successfully and inexpensively, and there is thus no reason why such restorations should not include large areas and be implemented widely. Among the tools for evaluating success are historical descriptions and various measures of biodiversity and vegetation condition.

Key Words: savannah, restoration, pine plantation, tree planting, species at risk, threatened, Ottawa, Ontario.

The loss of natural habitat to conifer plantations has occurred around the world. Recognition of this problem over the last several decades has led to removal of plantations and restoration of original vegetation in many areas. Some restoration projects have been extensive such as the replacement of a 2000 ha *Pinus radiata* plantation with indigenous plant communities in Australia (Kasel and Meers 2004*) .

In North America, savannahs and sand barrens are among the natural habitats often destroyed by development of conifer plantations. These habitats are also among the most imperilled of North American ecosystems (Noss et al. 1995). The problem is particularly well known in the southeastern United States where, prior to European settlement, extensive areas of species-rich Longleaf Pine (*Pinus palustris*) savannahs were maintained by naturally occurring, relatively frequent, low intensity fires (Taggart 1990*). By the 1950s the suppression of fire, logging, conversion of the landscape to agriculture and pine plantation forestry had reduced the ecosystem to scattered remnants amounting to less than 3% of the original area. Today the remnants of this formerly predominant ecosystem are the focus of major restoration efforts, many of which involve clearing of pine plantations (Gilliam and Pratt 2006; Brudvig et al. 2009). In the northern lower Michigan portion of the Great Lakes region, the once extensive Jack Pine barrens, have been mostly converted to managed Jack Pine plantations. These plantations are now being managed to create openings (Houseman and Anderson 2002) to restore the former barrens habitat for the endangered Kirtland's Warbler (*Dendroica kirtlandii*).

In Ontario between 1950 and 1970, extensive areas of open land, particularly dry, sandy, areas (including native savannahs), were planted with pines. These trees do well (especially with a head start) under dry conditions. This action was a leftover from a period when conservation was often seen in the limited context of erosion control. It was before the International Biological Program (IBP) that focused attention on ecosystems, ecology and significant natural habitats. The idea of the plantations was to prevent wind erosion resulting from intensive and poor agricultural practices and to increase productivity and value of idle land, often referred to as "wasteland." In 1971, Doug Clarke, former Chief of Wildlife Branch of the Ontario Department of Lands and Forests (and one of the most forward thinking biologists of the time), wrote of the unfortunate loss of the wildlife habitats (of Field, Grasshopper and Henslow's sparrows, etc.) to pine plantations throughout southern Ontatio. He correctly observed

FIGURE 1. A clearing of the planted forest created in the late 1980s as part of an attempt to restore a portion of The Sandhills ecosystem. The line of transect 1 crosses the opening perpendicular to the line of vision in the centre of the photo. Looking southwest from the northeast corner. Photo by P. M. Catling, September. 2009.

that "more wildlife species like it open, that edges and openings are the places for wildlife, and the great wildlife spectacles of the earth are on treeless, or nearly treeless lands." It is not always necessary to plant pines to restore wasteland (e.g., Catling and King 2008) and planting non-native pines has led to substantial losses of native biodiversity (e.g., Catling and Carbyn 2005). In some cases the "wastelands" of Ontario that were planted with pines were special places with large numbers of native species including many rarities. As a result of plantation forestry, they were largely reduced to monocultures of a single species of tree; species diversity declined and some, or many, rare species were extirpated. The Constance Bay Sandhills on the Ottawa River provide one of hundreds of examples of this largely unconscious depletion of natural resources during the middle 20th century (Catling et al. 2010). The Sandhills were, and to a degree still are, one of the biodiversity gems in the Ottawa valley, that was largely destroyed by conversion to a pine plantation.

Now that the importance of protecting biodiversity is more widely understood, complaints about the earlier misguided tree planting are frequent, but serious suggestions for restoration are few. Fewer still have been the attempts at restoration, although they are ongoing and the thinning and removal of plantations is a part of these restorations as for example in the Rice Lake Plains area of southern Ontario (Ontario Ministry of Natural Resources 2009*). Comprehensive evaluations of the success of restoration of savannah from pine plantation in Ontario are non-existent, yet landscape managers are in the position of making decisions on the basis of costs and benefits and restoration of imperiled savannah ecosystems in Ontario is a high priority (Bakowsky and Riley 1994; Rodger 1998).

The Constance Bay Sandhills, also known as Torbolton Forest (when the unique landscape could no longer be seen for the trees) is one of the few places in Ontario where restoration has been attempted. Here we evaluate the results of that effort to provide a basis for future restoration of savannahs and sand barrens. Specifically we provide an indication of success with respect to the amount of effort and provide an example of some considerations and procedures for estimating success.

FIGURE 2. The Red Pine (*Pinus resinosa*) plantation on the north side of the clearing. Left showing the height and density of trees looking northeast from the centre of the clearing. Right showing the very sparse vascular plant cover in deep pine needle litter along transect 3 in the plantation. Photos by P. M. Catling, September 2009.

Methods

The Study Area

The Constance Bay Sandhills are located on the south side of the Ottawa River in the western portion of the city of Ottawa at 45.49586°N, and -76.08684°W. For a general discussion of the biodiversity and history of the area see Catling et al. (2010) and for information on the flora see White (2004a, 2004b*). The restoration of The Sandhills was undertaken by the Ontario Ministry of Natural Resources (OMNR). The restoration area from which the trees were removed (subsequently referred to as the clearing) is a little less than a hectare in extent. It is mostly flat or gently sloping and lower than the surrounding land. The restoration involved removal of all planted Red and Jack Pine trees in the late 1980s from an area planted in the early 1950s (approximately 40 years earlier). The duff was not removed and the regeneration of savannah was initially poor. In 1989 OMNR staff Don Cuddy and Kim Taylor supervised removal of the duff to expose the sandy soil. Seeds from plants in the firebreaks were planted in both bare sand and in areas of remaining duff. Records of these plantings were kept but subsequently lost. The restoration work is estimated to have required five people over a period of less than two weeks. By 1991, many savannah plants had developed in the sandy areas including many that had not been planted (D. Cuddy, personal. communication). The OMNR intended the restored area to be the first step in an extensive restoration requested by professional biologists and local naturalists (Wilson 1984; Catling et al. 2010) but after the first steps in 1987–1992, OMNR experienced a series of cutbacks and the work ceased. Responsibility for management became unclear but it appears to have belonged to the township of Torbolton until it was turned over to the City of Ottawa in 2000. Over the last few decades there have been low intensity fires in parts of the clearing (regarded by biologists visiting the site as having been beneficial) that were evidently started by young people partying in the site (and/or possessing ecological knowledge).

To evaluate the effectiveness of the restoration it is necessary to determine the extent to which the restored area was dominated by native pre-plantation vegetation. In 1941, prior to the conversion of the savannah which dominated much of The Sandhills to a pine plantation, Porsild (1941) indicated that "on gently

sloping ground and in level places *Vaccinium pennsylvanicum* (= *angustifolium*), *Gaylussacia baccata, Myrica asplenifolia, Ceanothus americanus, C. ovatus* and *Arctostaphylos uva-ursi* form a dense cover." Later in 1957, but still in advance of destruction, Breitung (1957) described The Sandhills as "treeless and prairie-like in aspect, covered with low shrubs. Of these the primary species are *Vaccinium pensylvanicum* (= *angustifolium*), *Myrica asplenifolia, Ceanothus americanus, Prunus pumila* var. *cuneata* (= *susquehannae*), and *Gaylussacia baccata.*

From these historical landscape descriptions a successful restoration would include the establishment of a self-sustaining lower elevation, level area dominated by a dense growth of the previously mentioned dominant shrub species. Success was also considered with respect to biodiversity measures applied to the vascular flora and an indicator group of insects.

Data Collection

In September 2009, 17 years after the restoration clearing was created, vegetation was sampled with 20 one m^2 quadrats, 3 m apart along four transects, each 80 m long. Two of these transects were in the restoration clearing and two were in the adjacent plantation. The adjacent plantation samples included one planted with Red Pine (north side), the other planted with Jack Pine. Orthopteran insects (grasshoppers, crickets, katydids) were sampled by sweeping vegetation with a net and direct hand capture along the same four transects one m on either side of the transect line. The Orthoptera survey was carried out during clear, sunny weather and 45 minutes was spent collecting along each transect line. This amount of time was sufficient to capture and record all Orthopteran insects along the transects. The timing of the Orthopteran survey was appropriate since most species are adult at this time and some spring species that are only half grown nymphs are large enough to be identifiable.

Most insects and some plants are represented by voucher specimens in the CNCI and DAO collections of Agriculture and Agri-food Canada on the Central Experimental Farm in Ottawa. The names of orthopteroid insects correspond to those used in Vickery and Kevan (1985) and Cantrall (1968). The names of plants are taken largely from Kartesz and Meachum (1999).

Data Analysis

To determine the extent of successful restoration of native savanna vegetation at The Sandhills, the vegetation and orthopteran insect fauna of the two transects in the restored clearing was compared with that of two transects representing the surrounding plantation.

For vascular plants the species presence was recorded in each quadrat. Cover for each species in each quadrat was estimated as a percentage of the one m^2 ground surface covered by living material of that species. It could exceed 100% due to overlap of extensive cover. There was no height restriction so an estimate of tree cover was also included. This cover estimate corresponds to 1/2 of the surface area of a plant above a quadrat. Mean % frequency and mean % cover of species were compared between the restoration clearing and the adjacent plantation and within these two sites. The numbers of orthopteroid insects were simply tallied for comparison.

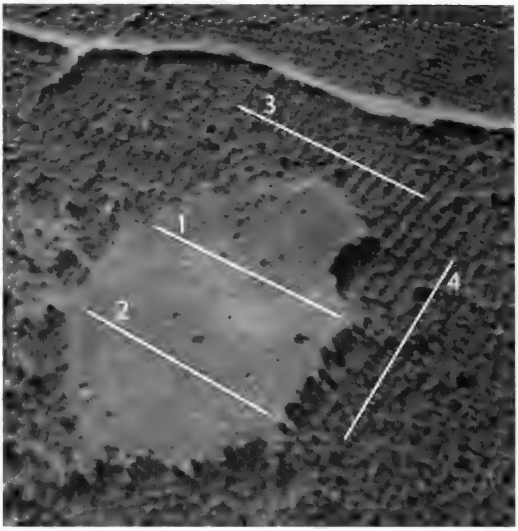


FIGURE 3. Aerial view of the opening showing the position of four transects. Reproduced from Google Earth Pro in 2009.

The measures of biodiversity employed were: (1) total number of species and individuals for both plants and orthopteroid insects (species richness) and for plants the frequency and cover of each species; (2) the number of regionally rare species for plants through reference to the list of "distributionally significant" species developed by Brunton (2005*); (3) the reciprocal of Simpson's Index based on probability which weights common and dominant species applied to both plant cover and frequency data; and (4) Brillouin's Index which employs numbers of individuals or in this case instances, (i.e., frequency), and assumes no replacement, applied only to frequency data. The computations were made using Ecological Methodology software (Krebs 2008*). See also Krebs (1999) for details on these biodiversity measures. The Simpson's and Brillouin's indices both take heterogeneity into account. This includes consideration of the number of common species and the evenness of occurrence. The reciprocal of Simpson's Index approximates the number of equally common species required to generate the heterogeneity observed in the sample. Biodiversity that includes a large number of equally common species is often perceived as more valuable than that which includes a few dominants accompanied by a large number of rare species.

TABLE 1. Mean % cover and mean % frequency of vascular plants in 20 one m^2 quadrats in each of four transects inside a cleared restoration area (1,2) and in surrounding plantation (3,4). Rows for dominant shrubs noted by Porsild (1941) and Breitung (1957) are shaded. Regionally rare species (Brunton 2005*) are indicated by an asterisk (*). The single introduced species is indicated by "I."

Species	*1* Clearing N		*2* Clearing S		*3* Plantation N *P. resinosa*		*4* Plantation E *P. banksiana*	
	Mean % cover	*Mean % Freq.*	Mean % cover	*Mean % Freq.*	Mean % cover	*Mean % Freq.*	Mean % % cover	*Mean % Freq.*
Acer rubrum L., Red Maple	–	–	–	–	–	–	0.25	*5*
Amelanchier laevis Wieg., Allegheny Service-Berry	–	–	–	–	–	–	0.05	*5*
Amelanchier stolonifera Wieg., Running Service-Berry	0.75	*5*	–	–	–	–	–	–
Anemone cylindrica Gray, Long-Head Thimbleweed	–	–	0.15	*5*	–	–	–	–
Antennaria sp., Pussytoes	6.05	*5*	–	–	–	–	–	–
Aquilegia canadensis, L., Red Columbine	–	–	–	–	–	–	0.70	*15*
Arctostaphylos uva-ursi (L.) Spreng., Red Bearberry	3.80	*10*	–	–	–	–	–	–
Photinia (*Aronia*) *melanocarpa* (Michx.) Robertson and Phipps, Black Chokeberry	–	–	0.40	*5*	–	–	–	–
Asclepias syriaca L., Common Milkweed	–	–	1.10	*5*		–	–	–
Calystegia spithamaea (L.) Pursh subsp. *spithamea,* Low False Birdweed *	0.15	*5*	–	–	–	–	–	–
Campanula rotundifolia L., Bluebell-of-Scotland	–	–	0.15	*5*	–	–	–	–
Carex pennsylvanica Lam., Pennsylvania Sedge	61.70	*100*	65.75	*100*	1.15	*10*	2.35	*7*
Carex tonsa (Fern.) Bickn. var. *rugosperma* (Mackenzie) Crins, Shaved Sedge	0.80	*20*	–	–	–	–	–	–
Carex siccata Dewey, Dry-spike Sedge *	–	–	0.10	*5*	–	–	–	–
Ceanothus herbaceous Raf. (*C. ovatus*), Prairie Redroot	7.20	*30*	4.55	*20*	–	–	0.80	*5*
Cypripedium acaule Ait., Pink Lady's-slipper	–	–	–	–	–	–	0.20	*10*
Danthonia spicata (L.) P. Beauv. *ex* Roemer & J.A. Schultes, Poverty Wild Oat Grass	4.10	*50*	1.05	*10*	–	–	–	–
Deschampsia flexuosa (L.) Trin., Wavy Hair Grass *	0.15	*5*	–	–	–	–	–	–
Dichanthelium (*Panicum*) *boreale* (Nash) Freckmann, Northern Rosette Grass *	1.85	*25*	0.45	*10*	–	–	–	–
Dichanthelium (*Panicum*) *depauperatum* (Muh.) Gould, Starved Rosette Grass *	5.80	*55*	0.85	*15*	–	–	–	–
Diphasiasrtrum (*Lycopodium*) *tristachyum* Pursh, Deep-Root Ground-Pine *	–	–	–	–	–	–	1.50	*5*
Dryopteris marginalis (L.) Gray, Marginal Wood Fern	–	–	–	–	0.65	*5*	–	–
Epigaea repens L., Trailing Arbutus *	–	–	–	–	–	–	0.15	*5*
Fragaria virginiana Duchesne subsp. *virginiana*, Virginia Strawberry	0.35	*5*	–	–	–	–	–	–
Frangula alnus P. Mill. (*Rhamnus frangula*), Glossy False Buckthorn (I)	–	–	–	–	1.25	*10*	0.40	*5*
Gaultheria procumbens L., Eastern Teaberry	–	–	–	–	–	–	2.40	*25*
Helianthemum canadense (L.) Michx., Long-Branch Frostweed *	4.15	*30*	–	–	–	–	–	–
Helianthus divaricatus L., Woodland Sunflower *	–	-	0.10	*5*	–	–	–	–
Lactuca sp.	–	–	0.50	*5*	–	–	–	–
Lechea intermedia Leggett *ex* Britt., Round-Fruit Pinweed *	0.10	*5*	–	–	–	–	–	–
Maianthemum canadense Desf. False Lily-of-the-Valley	–	–	–	–	–	–	0.35	*5*
Maianthemum (*Smilacina*) *stellatum* (L.) Link, Starry False Solomon's Seal	–	–	–	–	0.35	*5*	1.60	*20*

TABLE 1. *(continued)*

Species	*1* Clearing N		*2* Clearing S		*3* Plantation N *P. resinosa*		*4* Plantation E *P. banksiana*	
	Mean % cover	*Mean % Freq.*	Mean % cover	*Mean % Freq.*	Mean % cover	*Mean % Freq.*	Mean % % cover	*Mean % Freq.*
Muhlenbergia glomerata (Willd.) Trin., Spiked Muhly	1.60	*10*	–	–	–	–	0.05	*5*
Myrica peregrina (L.) Coult., (*M. asplenifolia*), Sweet Fern	16.20	*70*	13.30	*65*	–	–	–	–
Orthilia (*Pyrola*) *secunda* (L.) House, Sidebells	–	–	–	–	–	–	0.10	*5*
Oryzopsis asperifolia Michx., White-Grain Mountain-Rice Grass	–	–	–	–	–	–	1.45	*15*
Pinus banksiana Lamb., Jack Pine *(native only)	–	–	–	–	–	–	41.05	*90*
Pinus resinosa Ait., Red Pine	–	–	–	–	105.5	*100*	–	–
Pinus strobus L., Eastern White Pine	–	–	–	–	2.50	*25*	–	–
Piptatherum (*Oryzopsis*) *pungens* (Torr.) Barkworth, Short-Awn Mountain-Rice Grass *	0.30	*15*	0.70	*20*	4.90	*55*	0.85	*45*
Poa pratensis L., Kentucky Blue Grass	0.50	*5*	–	–	–	–	–	–
Polygala polygama Walt., Racemed Milkwort *	0.10	*5*	0.30	*10*	–	–	-	-
Populus tremuloides Michx. Quaking Aspen	–	–	–	–	13.50	*15*	3.80	*25*
Prunus susquehannae Willd., Susquehanna Sand Cherry *	4.30	*40*	8.70	*5 0*	–	–	1.45	*45*
Pteridium aquilinum (L.) Kuhn, Northern Bracken Fern	4.60	*20*	0.40	*5*	0.45	*5*	13.40	*50*
Quercus macrocarpa Michx., Burr Oak	–	–	–	–	–	–	2.25	*5*
Quercus rubra L., Northern Red Oak	0.60	*5*	0.75	*5*	–	–	1.25	*5*
Rosa blanda Ait., Smooth Rose	–	–	–	–	–	–	0.80	*5*
Rosa nitida Willd., Shining Rose	–	–	–	–	–	–	0.55	*10*
Rubus allegheniensis Porter, Allegheny Blackberry	13.00	*65*	6.20	*40*	–	–	4.45	*55*
Salix humilus Marsh., Prairie Willow	4.00	*10*	2.60	*10*	–	–	0.95	*10*
Schizachyrium (*Andropogon*) *scoparium* (Michx.) Nash var. *scoparium,* Little False Bluestem *	3.90	*25*	–	–	–	–	–	–
Solidago hispida Muhl. ex. Willd., var. *hispida,* Hairy Goldenrod	–	–	–	–	–	–	0.60	*5*
Solidago juncea Ait., Early Goldenrod	–	–	0.75	*5*	–	–	–	–
Solidago nemoralis Ait., var. *nemoralis*, Gray Goldenrod	–	–	0.60	*5*	–	–	–	–
Sorghastrum nutans (L.) Nash, Yellow Indian Grass *	1.10	*5*	–	–	–	–	–	–
Spiraea alba Du Roi, White Meadosweet	5.95	*30*	17.50	*65*	–	–	0.60	*5*
Symphyotrichum (*Aster*) *ciliolatus* (Lindl.) A and D Löve, Lindley's American Aster	–	–	1.50	*5*	–	–	0.10	*5*
Toxicodendron radicans (L.) Kuntze subsp. *radicans,* Eastern Poison Ivy	0.25	*5*	–	–	–	–	–	–
Trientalis borealis Raf., Maystar	–	–	–	–	–	–	–	–
Vaccinium angustifolium Ait., Late Lowbush Bluebeerry	13.55	*100*	8.45	*40*	1.25	*10*	6.90	*85*
Viola adunca Sm., var. *adunca*, Hook-Spur Violet *	1.00	*20*	0.10	*10*	–	–	–	–
Viola fimbriatula Ait. var. *ovata* (Nutt.) Torr. & Gray, (*V. saggitata*) Arrow-leaf Violet *	2.20	*30*	0.25	*5*	–	–	–	–
BRYOPHYTES (*Polytrichum*)	1.80	*20*	–	–	–	–	–	–
BRYOPHYTES (other)	–	–	–	–	–	–	71.25	*95*
LICHENS	4.50	*45*	–	–	–	–	–	–

TABLE 2. Orthopteroid insects along each of four transects inside a cleared restoration area (1,2) and in surrounding plantation (3,4). Data collected in mid September 2009.

	1	2	3 Plantation	4 Plantation
Total	Clearing	Clearing	N	E
Species	N	S	(*P. resinosa*)	(*P. banksiana*)
Melanoplus bivitattus (Say), Two-striped Grasshoper	2	4	–	–
Melanoplus keeleri luridus (Dodge), Broad-necked Grasshopper	12	8	–	–
Melanoplus punctulatus punctulatus (Scudder), Grizzly Grasshopper	1	1	7	1
Melanoplus fasciatus (F. Walker), Huckleberry Grasshopper	8	6	–	–
Melanoplus sanguinipes sanguinipes (Fabricius), Migratory Grasshopper	14	12	–	–
Spharagemon bolli bolli Scudder, Boll's Grashopper	10	6	–	–
Orphulella speciosa (Scudder), Pasture Grasshopper	4	3	–	–
Chloealtis abdominalis (Thomas), Rocky Mountain Sprinkled Grasshopper	1	7	–	–
Chorthippus curtipennis curtipennis (Harris), Marsh Meadow Grasshopper	7	9	–	–
Scudderia curvicauda (De Geer), Curve-tailed Bush Katydid	2	3	–	–
Nomotettix cristatus cristatus (Scudder), Northern Crested Pygmy Grasshoper	5	2	–	–
Gryllus pennsylvanicus Burmeister, Fall Field Cricket	11	13	–	–
Allonemobius allardi (Alexander & Thomas), Allard's Ground Cricket	20	20	–	–
Chortophaga viridifasciata (De Geer), Green-striped Grasshopper	5	5	–	–
TOTALS	102	99	7	1

In some situations plant diversity may be high but individuals may be small and or weak and non-productive with implications for dependent species in the ecosystem such as plant-feeding insects and insect- and plant-eating birds. To evaluate this visually, we have used graphs of ranked (highest to lowest) cover values without the single dominant species (*Carex pennsylvanica* in the clearing and Red Pine or Jack Pine in the plantation) where the greater the area below the graph line indicates greater contribution to the total cover of non-dominant species, suggesting better "condition" of sub-dominants.

Results

Return to Savannah Vegetation

Of the seven native shrubs reported by Porsild (1941) and Breitung (1957) as characteristic of the savannah, five (*Arctostaphylos uva-ursi, Ceanothus ovatus, Myrica asplenifolia, Prunus susquehannae, Vaccinium angustifolium*) were present in the restored area and most were dominants. The major dominant in the restored area was the native sedge *Carex pensylvanica*, a characteristic species of savannah. With the dominance of a characteristic native graminoid plant and the same native shrubs reported as pre-plantation dominants, the natural vegetation appears to have been successfully restored.

Biodiversity Increase

The two clearing transects and the Jack Pine plantation transect had similar numbers of vascular plant species and similar values for various biodiversity index measurements that were much higher than those for the Red Pine plantation (Table 2).

With regard to rare species (as defined in White 2004a, b) that were seen within 10 m of transects, there were only three in the surrounding plantation: Piptatherum (*Oryzopsis*) *pungens* occurred in both the Red Pine and Jack Pine; *Epigaea repens* and *Diphasiastrum* (*Lycopodium*) *tristachyum*, occurred only in the latter. The situation was very different in the clearing transects where a total of 19 regionally rare species were present within 10 m of transects including: *Bromus kalmii, Calystegia spithamaea* subsp. *spithamea, Carex siccata, Cyperus houghtonii, Deschampsia flexuosa, Dichanthelium* (*Panicum*) *boreale, Dichanthelium* (*Panicum*) *depauperatum, Elymus canadensis, Helianthemum canadense, Helianthus divaricatus, Lechea intermedia, Lithospermum caroliniense* var. *croceum, Piptatherum* (*Oryzopsis*) *pungens, Polygala polygama, Prunus susquehannae, Rubus pennsylvanicus, Schizachyrium* (*Andropogon*) *scoparium* var. *scoparium, Sorghastrum, nutans, Viola adunca* var. *adunca,* and *Viola fimbriatula* var. *ovata.* A similar occurrence of regionally rare species can be seen in the quadrat data (Tables 1 and 3).

The only introduced plant observed in the plantation was *Frangula alnus*. Since it had low frequency and cover values there was no need to take this species into

TABLE 3. Number of vascular plant species, number of rare (distributionally significant) following Brunton (2005*) and values for the Brillouin's and reciprocal of Simpson's biodiversity indices for each of four transects inside a cleared restoration area (1,2) and in surrounding plantation (3,4).

	Total Species	1 Clearing N	2 Clearing S	3 Plantation N P. resinosa	4 Plantation E P. banksiana
Number of species	63	33	27	10	31
Number of rare species	15	13	9	1	3
Brillouin's Index (freq.)	n/a	4.198	3.748	2.413	3.963
Simpson's Index (cover)	n/a	15.223	9.999	4.042	12.218
Simpson's Index (freq.)	n/a	16.818	10.804	4.040	12.472

account at the present time, but given its seriously invasive nature (Catling and Porebski 1994) it is conceivable that it will impact future restoration as it becomes more common in the area.

The ranked cover graphs indicated that the clearing transects had greater cover of non-dominant species (Figure 4), suggesting that more shrubby and herbaceous species were in good condition than in the plantation transects. This was confirmed by visual observation of a number of species, such as *Vaccinium angustifolium* and *Prunus susquehannae*. Both were fairly frequent in the Jack Pine plantation transect, but rarely produced flowers or fruit there. Abundant flower and fruit production by robust shrubs of both of these species was observed in the clearing transects.

Re-establishment of Orthopteroid Insects

The diversity of orthopteropid insects was much higher in the clearing (Table 3), where 14 species and 201 individuals were recorded, as opposed to eight individuals of one species in the surrounding plantation. The only species found in the pine plantation was *Melanoplus punctulatus punctulatus*, which lives in and feeds on Red Pine. Among the species present in the clearing, the populations of *Spharagemon bolli bolli* and *Melanoplus fasciatus* constitute impressive occurrences of locally uncommon species strongly associated with natural, open habitats. The former is usually associated with open sand with sparse grass and shrub cover. The latter is associated with open areas with huckleberry and/or blueberry (Vickery and Kevan 1985).

Discussion

Return to Savannah Vegetation

A limitation of the present restoration attempt was the small geographic area involved, which in the context of the landscape, results in a lack of topographic variation. The restored area is low and flat. Had it been larger, it may have included higher and steeper areas and it would likely have included different assemblages of species and more domination by those preferring drier and sandier conditions. Regardless of this limitation, the restoration of pre-settlement and pre-plantation vegetation based on limited effort was successful.

Biodiversity Increase

The fact that the Jack Pine plantation transect had higher biodiversity than one of the clearing transects may be explained by the fact that these pines with relatively open canopies were established in an open area of original vegetation that was able to survive in a depleted condition due to the continuation of somewhat open conditions. The remnant species of open habitats along with species of more shaded conditions that spread into the plantation apparently combined to produce a relatively high diversity. The Red Pine plantation excluded much more light and also gave rise to dense needle litter which buried ground flora.

Although the Jack Pine plantation had biodiversity values approaching that of the restored clearing, the smaller number of regionally rare species resulted in a lower level of biodiversity significance there. Furthermore the smaller amount of non-dominant vegetation cover in the Jack Pine plantation, than in the clearing, attests to the poor condition of much of the plantation flora with a resultant lesser value to pollinators and plant-feeding insects.

Re-establishment of Orthopteroid Insects

The much higher diversity of an indicator group of plant dependent insects in the clearing is not surprising considering the higher plant diversity and better condition of the flora, and the general finding that insect diversity tracks plant diversity (e.g. Knops et al. 1999). The origin of these insects is an interesting question since they were not found in the adjacent plantation. It seems most likely that they followed open habitat along paths and firebreaks into the site. It is also conceivable that they persisted in very low numbers in the Jack Pine plantation where the ground flora persisted in a depleted condition.

Conclusions

The restoration of savannah from pine plantation has not been extensive enough in Ontario to provide evidence for success on the basis of statistical analysis of many replicated samples. This study however, does provide some useful evidence pertaining to a single situation. It strongly suggested that restoration of a savannah destroyed by a pine plantation can be eas-

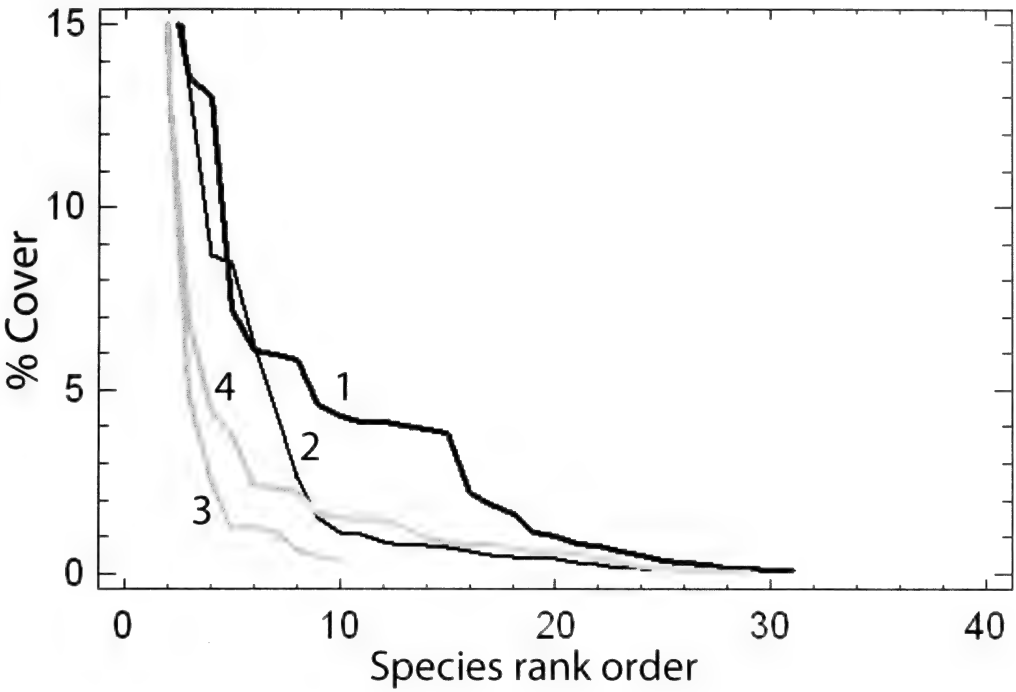


FIGURE 4. Graphs of ranked (highest to lowest) cover values without the single dominant species (*Carex pennsylvanica* in the clearing and Red Pine or Jack Pine in the plantation). The greater the area below the graph line indicates greater contribution to the total cover of non-dominant species, suggesting better "condition" of sub-dominant species.

ily accomplished, especially if remnants of the previous ecosystem remain in the immediate vicinity and if some are introduced during the early stages of restoration. The importance of a local source of plants for recolonization has been established in other studies (Brudvig et al. 2009). In the present situation, both plants and insects may have been able to take advantage of open edges along paths as dispersal corridors.

Not only was the savannah vegetation restored but native biodiversity in The Sandhills study area was also substantially promoted by returning the plantation to savannah. The results have included: (1) major increase in the number of regionally rare species; (2) improvement in the condition of species of open habitat compared to that seen in the plantation; and (3) vast improvement in the diversity and abundance of an indicator group of plant dependent insects which occurred without direct intervention. Tools for monitoring and measuring success include historical descriptions, and data from quadrats leading to comparisons of diversity, biodiversity indices and species rank order graphs. At this site and at all others where restoration actions have been taken there should be continuing monitoring to establish the extent and continuation of beneficial effects. Both here and elsewhere the restoration should be extended to the maximum possible extent so as to protect the largest amount of biodiversity. Considering the relatively low costs there is no reason not to indulge in extensive restoration of open habitat on plantation lands.

Acknowledgments

Don Cuddy and Sean Thompson of the Ontario Ministry of Natural Resources provided background materials. Don Cuddy shared information from his personal notebooks. Jeff Skevington and Dan Brunton kindly commented on the manuscript.

Documents Cited (marked * in text)

Brunton, D. F. 2005. Vascular plants of the City of Ottawa, with identification of significant species, Appendix A of Muncaster Environmental Planning and Brunton Consulting Services. 2005. Urban Natural Areas Environmental Evaluation Study, Final Report. Planning and Growth Management Department, City of Ottawa, Ottawa.

Kasel, S. and **T. Meers**. 2004. Restoration of former pine plantations in Australia: Revegetation techniques, pine wildling control, and the importance of land use history. Society for Ecological Restoration International Online. https://www.ser.org/serbc/pdf/287_former_pine_plantations_Australia.pdf.

Krebs, C. 2008. Ecological Methodology, programs for ecological methodology, 2nd edition. Exeter Software, Setauket, New York.

Ontario Ministry of Natural Resources. 2009. Peter's Woods Park Management Plan. Darlington Provincial Park. Bowmanville. 51 pages.

Taggart, J. B. 1990. Inventory, classification and preservation of coastal plain savannas in the Carolinas. Ph.D. dissertation, University of North Carolina, Chapel Hill, North Carolina.

White, D. J. 2004a. Rare plant inventory and management recommendations for Torbolton Forest. Transportation, Utilities and Public Works Department, City of Ottawa.

White, D. J. 2004b. Rare plant manual. Transportation, Utilities and Public Works Department, City of Ottawa.

Wilson, S. 1984. Restoration of the native vegetation of the Constance Bay Sandhills, Regional Municipality of Ottawa-Carleton. The Plant Press 2(1): 6-7.

Literature Cited

Bakowsky, W., and **J. Riley.** 1994. A survey of the prairies and savannas of southern Ontario. Pages 7-16 *in* Proceedings of the Thirteenth North American Prairie Conference: Spirit of the Land, Our Prairie Legacy. August 6-9, 1992. *Edited by* R. Wickett, P. Dolan Lewis, A. Woodliffe and P. Pratt, Corporation of the City of Windsor, Windsor, Ontario.

Breitung, A. J. 1957. Vascular flora on the sand dunes at Constance Bay, Ontario. Le Naturaliste canadien 84 (3-4): 79-87.

Brudvig, L. A., E. I. Damschen, J. J. Tewksbury, N. M. Haddad and **D. J. Levey.** 2009. Landscape connectivity promotes plant biodiversity spillover into non-target habitats. Proceedings of the National Academy of Sciences of the United States of America. 106(23): 9328-9332.

Cantrall, I. J. 1968. An annotatred list of the Dermaptera, Dictyoptera, Phasmatoptera, and Orthoptera of Michigan. Michigan Entomologist 1: 299-346.

Catling, P. M., and **S. Carbyn.** 2005. Invasive Scots Pine (*Pinus sylvestris*) replacing Corema (*Corema conradii*) heathland in the Annapolis valley, Nova Scotia, Canada. Canadian Field-Naturalist 119: 237-244

Catling, P. M., and **B. King.** 2008. Natural recolonization of cultivated land by native prairie plants and its enhancement by removal of Scots Pine, *Pinus sylvestris.* Canadian Field-Naturalist 121: 89-91.

Catling, P. M., and **Z. S. Porebski.** 1994. The history of invasion and current status of Glossy Buckthorn, *Rhamnus frangula*, in southern Ontario. Canadian Field-Naturalist 108: 305-310.

Catling, P. M., K. Spicer, and **D. F. Brunton.** 2010. The history of the Constance Bay Sandhills – decline of a biodiversity gem in the Ottawa valley. Trail and Landscape 44(1): 106–122.

Clarke, C. H. D. 1971. The cult of the Red Pine. Ontario Naturalist 9: 14-15.

Gilliam, F. S., and **W. J. Platt.** 2006. Conservation and restoration of the *Pinus palustris* ecosystem. Applied Vegetation Science 9: 7-10.

Houseman, R. C., and **R. C. Anderson.** 2002. Effects of Jack Pine plantation management on barrens flora and potential Kirtland's Warbler nest habitat. Restoration Ecology 10: 27-36.

Kartesz, J. T., and **C. A. Meacham.** 1999. Synthesis of the North American Flora, Version 1.0 North Carolina Botanical Garden, Chapel Hill, North Carolina.

Knops, J. M., H., D. Tilman, N. M. Haddad, S. Naeem, C. E. Mitchell, J. Haarstad, M. E. Ritchie, K. M. Howe, P. B. Reich, E. Siemann, and **J. Groth**. 1999. Effects of plant species richness on invasion dynamics, disease outbreaks, insect abundances and diversity. Ecology Letters 2: 286-293.

Krebs, C. 1999. Ecological methodology, 2nd edition. Addison, Wesley Longman Inc., New York. 620 pages.

Noss, R. F., E. T. LaRoe III, and **J. M. Scott.** 1995. Endangered ecosystems of the United States: a preliminary assessment of loss and degradation. Biological Report 28. U.S. Department of Interior, National Biological Service, Washington, D.C., 58.

Porsild, A. E. 1941. A relic flora on sand dunes from the Champlain Sea in the Ottawa valley. Canadian Field-Naturalist 55: 66-72.

Rodger, L. 1998. Tallgrass Communities of Southern Ontario: A Recovery Plan. World Wildlife Fund Canada and the Ontario Ministry of Natural Resources. 66 pages. www.tallgrassontario.org/Publications/TallgrassRecoveryPlan.pdf

Vickery, V. R., and **D. K. M. Kevan.** 1985. The insects and arachnids of Canada, part 14. The grasshoppers, crickets and related insects of Canada and adjacent regions. Ulonata: Dermaptera, Cheleutoptera, Notoptera, Dictuoptera, Grylloptera, and Orthoptera. Agriculture Canada Research Branch Publication 1777. Ottawa. Ontario. 918 pages.

Received 16 April 2010
Accepted 4 June 2010

Notes

Do Barrow's Goldeneyes, *Bucephala islandica,* Breed South of the St. Lawrence Estuary in the Gaspé Peninsula, Eastern Canada?

JEAN-FRANÇOIS OUELLET[1], PIERRE FRADETTE[2], and ISABEL BLOUIN[3]

[1]Département de biologie, chimie et géographie, Université du Québec à Rimouski, 300 allée des Ursulines, Rimouski, Québec, G5L 3A1 Canada; e-mail: jean-francois_ouellet03@uqar.qc.ca
[2]Regroupement Québec Oiseaux, 4545 Pierre-de-Coubertin, C. P. 1000, succ. M, Montréal, Canada
[3]Auberge de montagne des Chic-Chocs, 10 Notre-Dame Est, C.P. 120, Cap-Chat, Québec, Canada

Ouellet, Jean-François, Pierre Fradette, and Isabel Blouin. 2010. Do Barrow's Goldeneyes, *Bucephala islandica,* breed south of the St. Lawrence estuary in the Gaspé Peninsula, Eastern Canada? Canadian Field-Naturalist 124(2): 179–180.

We report the first observations of Barrow's Goldeneyes south of the St. Lawrence estuary in typical breeding habitat during the breeding season. Until recently, the confirmed breeding locations for the species in Eastern North America were all located on the north shore of the Estuary and Gulf of St. Lawrence.

Key Words: Barrow's Goldeneye, *Bucephala islandica*, Chic-Chocs Mountains, Gaspé Peninsula.

The presence of the Barrow's Goldeneye (*Bucephala islandica*) in Eastern North America has been known for more than a century (Coues 1903; Dionne 1906), but little was known about this population until recently (Savard 1995; Savard and Dupuis 1999). For instance, its breeding area was only defined in the early 1990's (Robert et al. 2000a). Since then, the population has been designated as "of special concern" by the committee on the status of endangered wildlife in Canada (COSEWIC 2001) and is now protected under the federal Species at Risk Act. The Barrow's Goldeneye breeds in the boreal forest along the north shore of the St. Lawrence estuary and it has never been reported breeding on the south shore. Degradation of its breeding habitat was identified as a potential threat on the population (Robert et al. 2000b*), but the actual extent of the breeding range is largely unknown. Most of our current knowledge of the delineation of Barrow's Goldeneye's breeding ground in Eastern North America was provided by radio-tracking and aerial and ground surveys (Robert et al. 2000a, 2002; SOS-POP 2009). The breeding location data, although accurate, are far from exhaustive. Also, there is still place for fortuitous discoveries. We report here on the first observations of Barrow's Goldeneyes south of the St. Lawrence estuary in typical breeding habitat during the breeding season.

Results and Discussion

Two lakes in high altitude in the Chic-Chocs Mountains, Lake Bardey (48°51'N; 66°42'W) and Lake Coleman (48°52'N; 66°42'W), were visited on 25 and 26 June and on 9 and 18 July 2009. On 25 June, an adult male Barrow's Goldeneye was observed on Lake Bardey and an adult female was observed on Lake Coleman. On Lake Bardey, the male was accidentally flushed upon the observer's approach and landed in the middle of the lake. During the following ten minutes, it exhibited an alarmed attitude and was repeatedly seen calling, possibly suggesting the presence of another undetected individual in the area. On Lake Coleman, the female was engaged in preening activities during most of the 70 minute period it was observed. On 26 June, the male was not detected on either lakes but a female was observed roosting on the same outcrop on the bank of Lake Coleman. The individuals were found on different lakes located 300 m apart and were never seen together. Therefore, there are no indications whether the two individuals belonged to the same pair. Observations were conducted within 200 m of the birds in good light conditions with a Swarovski spotting scope of 80 mm fit with a 20-60× eyepiece. The male was in full breeding plumage and could not be mistaken with any other species. The identification of the female was ascertained afterwards by comparing field notes with close-up photographs of adult and juvenile female Barrow's and Common Goldeneyes (*Bucephala clangula*) archived at the Canadian Wildlife Service. On 9 July, an adult female was observed on Lake Bardey. On 18 July, no individuals were detected on either lakes. Since the individuals were not marked, we have no certitude whether our observations involved multiple females or repeatedly the same one. These observations constitute the first record of the presence of Barrow's Goldeneyes in breeding habitat during breeding season south of the St. Lawrence estuary.

The mountain guides affiliated to the Auberge de montagne des Chic-Chocs had noted the presence of pairs and ducklings of unidentified goldeneyes on the

exact same lakes repeatedly over the last few years (I. Blouin, unpublished data), which suggests that Barrow's Goldeneyes may have been nesting in this area for at least a couple of breeding seasons. The environment and features of lakes Bardey and Coleman fit well the description of the breeding habitat of Barrow's Goldeneyes in Eastern North America (Robert et al. 2006): Lake Coleman is a headwater lake lying at an altitude of 646 m and Lake Bardey is located 300 m downstream from Lake Coleman and is approximately 25 m lower in altitude; they are connected to the local watershed by a single stream cut by a 50 m high waterfall which may have prevented the colonization of these lakes by fish; both lakes are surrounded by steep slopes and a large proportion of their bank consisted of outcrops; they are free of riparian wetlands and no emergent vegetation was apparent at the date of our visit; and large snags are abundant in the landscape surrounding the lakes.

In our opinion, the most plausible explanation for the presence of the species in this area at this time of year is nesting. Other potential explanations include a migratory stop-over and a moult staging. But at the time of year when the observations were made (June and July), a migratory stop-over is very unlikely. Also, male Barrow's Goldeneyes moult in coastal environments and females moult on large lakes and both sexes winter at sea (Robert et al. 2000b*). Therefore, despite the lack of direct evidence of nesting, our observations extend the probable breeding range of the Eastern North American population of Barrow's Goldeneye to the Gaspé Peninsula. Our discovery also indicates that the land use and natural resource management of the Chic-Chocs Mountains should take into account the presence of this species at risk.

Acknowledgments

The authors thank Christian Marcotte who assisted in the identification of the female Barrow's Goldeneye and Jean-Pierre L. Savard for helpful comments for the interpretation of the observation. Luc Robichaud and Dominique Gagnon from the Société des établissements de plein air du Québec facilitated the access to the area. Joël Bêty, Leesia C. Marshall, Jean-Pierre L. Savard, and Anthony J. Erskine commented early versions of the manuscript and Leesia C. Marshall improved the English. The field expedition was funded by the Comité pour l'établissement d'une aire protégée dans les Chic-Chocs de la Réserve faunique de Matane.

Documents Cited (marked * in text)

Robert, M., Benoît, R., and **Savard, J.-P. L.** 2000b. COSEWIC status report on the eastern population of the Barrow's Goldeneye (*Bucephala islandica*) in Canada. Committee on the Status of Endangered Wildlife in Canada, Ottawa, Ontario.

Literature Cited

Committee on the status of endangered wildlife in Canada. 2001. Canadian species at risk, May 2001. Environment Canada, Ottawa, Ontario.

Coues, E. 1903. Key to North American Birds. Dana Estes and Company Boston, Massacusetts.

Dionne, C.-E. 1906. Les oiseaux de la province de Québec. Dussault & Proulx, Québec. 414 pages.

Robert, M., R. Benoît, and **J.-P. L. Savard**, **G. Fitzgerald,** and **F. Morneau.** 2000a. The breeding range of the Barrow's Goldeneye in eastern North America. Wilson Bulletin 112: 1-7.

Robert, M., Drolet, B., and **Savard, J.-P. L.** 2008. Habitat features associated with Barrow's Goldeneye breeding in Eastern Canada. The Wilson Journal of Ornithology 120: 320-330.

Savard, J.-P. L. 1995. Barrow's Goldeneye. *In* The Breeding Birds of Québec: Atlas of the Breeding Birds of Southern Québec. *Edited by* J. Gauthier and Y. Aubry. Association québécoise des groupes d'ornithologues (AQGO), The Province of Québec Society for the Protection of Birds (PQFPB), Canadian Wildlife Service (CWS), Québec Region, Environment Canada.

Savard, J.-P. L., and **P. Dupuis.** 1999. A case for concern? The eastern population of Barrow's Goldeneye (*Bucephala islandica*). Pages 66-76 *in* Behaviour and ecology of sea ducks. *Edited by* I. Goudie, M. R. Petersen and G. J. Robertson. Occasional Paper Number. 100, Canadian Wildlife Service, Ottawa.

SOS-POP. 2009. Banque de données sur les oiseaux en péril du Québec. Gérée par le Regroupement QuébecOiseaux avec l'appui d'Environnement Canada, Service canadien de la faune.

Received 6 April 2010
Accepted 7 June 2010

Psilolechia clavulifera, a Lichen Species New to Canada

CHRIS LEWIS

P.O. Box 1384, Lakefield, Ontario K0L 2H0 Canada; e-mail: cjl@niblettenvironmental.on.ca

Lewis, Chris. 2010. *Psilolechia clavulifera*, a lichen species new to Canada. Canadian Field-Naturalist 124(2): 181–182.

Psilolechia clavulifera is reported as new to Canada, where it was been found growing under a shaded rock overhang near Temagami, Ontario. This is the first record of the species for Canada. This occurrence represents only the fourth documented record of the species for North America since it was first discovered in 1939 by J. Lowe. This specimen was found growing with other rarely collected cryptic species found in unique microhabitats: *Psilolechia lucida, Protothelenella corrosa,* and *Microcalicium arenarium.*

Key Words: *Psilolechia clavulifera,* lichen, new to Canada.

Psilolechia clavulifera (Nyl.) Coppins was described in 1939 as *Lecidea adirondackii* by Josiah L. Lowe (Lowe 1939) based on material from the Adirondack Mountains of New York. The first North American collections from New York were made some 70 years ago, between the years 1932 and 1935. The type specimen is from the Huntington Forest near Newcomb, New York in Essex County (44'00°N, 74'13°W). In spite of the numerous floristic studies and the increased interest in lichens during the past 70 years, no recent collections have been made, even in New York. A 1990 collection, however, is stored in the Arizona State University (ASU) herbarium collected from the state of Washington. The notes on ecology and associations described here in the first Canadian record will hopefully help other lichenologists find this species.

There are three species of *Psilolechia* found in North America and Greenland: *P. lucida*, *P. clavulifera*, and *P. leprosa* (the last being found growing on copper-rich rock so far reported only from Greenland). *P. lucida* and *P. clavulifera* are both typically found on vertical or overhung rock substrates in shaded humid situations (Coppins and Purvis 1987; Wirth 1995) with *P. lucida* also being found growing on old wood (Brodo et al. 2001). A review of *Psilolechia* Massal by Coppins and Purvis (1987) describes a fourth species, *P. purpurascens*, known only from Tasmania.

Methods

Specimens collected and identified by the author were presented to Dr. Irwin Brodo at the Canadian Museum of Nature for verification. The specimens were studied using standard microscopic techniques, and vouchers were deposited in the National Herbarium of Canada lichen collection (CANL).

Observations

Specimens Examined

Canada. *Ontario*: TEMAGAMI DISTRICT: South Lorrain Township, (approx 17.5 km E of Temagami and approximately 82 km north of North Bay, underside of a rock overhang, on a treed talus slope, on the shore of the Matabichuan River.), 47°3'45"N, 79°33'25"W, *C. Lewis 165* (OAC University of Guelph), *C. Lewis 166* (CANL – #122546), June 28th, 2008; **Czech Republic**.

Psilolechia clavulifera (Nyl.) Coppins, Bulletin of the British Museum (Natural History), Botany Series **11(2)**: 17-214. 1983. *Lecidea clavulifera* Nyl. In Flora Jene 52: 294 (1869).

Synonyms: *Lecidea adirondackii* H. Magn., *Micarea clavulifera* (Nyl.) Coppins & P. W. James

Thallus: forming small patches, granular to granular-verrucose, the granules elongate or irregular, 14-33 x 1.0-14 µm, often growing together, effuse; ***surface:*** white to pale greenish gray (yellowish green to dark green according to Lowe); ***photobiont:*** *Stichococcus*; ***Apothecia:*** frequent, 0.1-0.3(-0.4) mm diameter, globose to tuberculate, convex to hemispherical; discs dark brown to blue-black or sometimes livid blackish or reddish brown; often surrounded by a basal white rim of protruding excipular hyphae (byssoid); hypothecium hyaline to pale green (pale olivaceous to green-black according to Lowe); hymenium pale greenish to blue-greenish; epihymenium pale green to blue-green (olivaceous or greenish black according to Lowe), K+ greenish, N+ purple-red; ascospores 4-7 × 1.2-2.0 µm, tear-shaped, (oblong-ovoid); ***Anamorph:*** frequent, the thallus surface often with scattered conidiogenous cells 7-12 × 1-2 µm, ± cylindrical (no pycnidia observed); ***conidia:*** 7-15 x 2-2.3 µm, ± oblong; ***Chemistry:*** thallus K-, C-, KC-, P-, UV-; no lichen substances.

Substrate and ecology: On roots, stones and firm or compacted soil under dry overhangs on banks or the root systems of fallen trees, rarely on bark (Wirth 1995; Ryan 1994-1999*, Purvis et al. 1992; Coppins and Purvis 1987; Czarnota and Kukwa 2008). Other lichen species often found in similar habitats include: *Chaenotheca furfuracea, Psilolechia lucida,* and *Microcalicium arenarium. Psilolechia lucida* is relatively rare in Ontario (Wong and Brodo 1992). ***Distribution:*** The North American distribution of *P. clavulifera* is relatively unclear due to its relatively few documented occurrences: Ontario, New York, and Washington. It

is known in Canada from a single locality. In Europe *P. clavulifera* has been reported from Iceland, United Kingdom, Norway, Germany, Austria, Sweden, and Czechoslovakia (GBIF, 2008*), Poland (Czarnota and Kukwa 2008), Finland (Coppins and Purvis 1987) and Italy (Benesperi et al. 2007). It has been found historically in Australia, New Zealand, Costa Rica, and Hawaii (Coppins and Purvis 1987). It was also recently reported new from South American when it was found in Bolivia (Flakus et al. 2006) and (Wirth 1995) considered it as rare but recent findings has indicated that it is more common than once thought. New data clearly shows that this species is much more widespread, and especially in boreal/pre-Cambrian rock regions it should be regarded as quite common lichen and is just potentially overlooked (Czarnota and Kukwa 2008).

BOHEMIA centralis, distr. Příbram, Brdy Hills: near lake/reservoir "Hořejší Padrt'ský Rybník", elevation 640 m, amongst Piceae sp. roots on soil, Š. Bayerová, April 5th, 1998 (ASU): **United States of America**. *New York*: ESSEX COUNTY, Huntington Forest at Newcomb near the Chapel Pond, on rock on talus slope, Lowe 4096 (CANL - #23646), August 13, 1934. ESSEX COUNTY, Huntington Forest at Newcomb, Lichens of New York State, on rock on talus slope, Lowe 4359 (CANL - #4664), August 20, 1934 *Washington*: SKAMANIA COUNTY: Carson National Fish Hatchery, on shaded underside of log, 45°50'N, 121°59'W, J. Davis, ca. 1990 (ASU).

Key to *Psilolechia* in North America and Greenland

1. Thallus bright greenish yellow, or completely yellow, UV+ dull to bright orange (rhizocarpic acid). Apothecia yellow-green to pale or lemon yellow or yellow-orange, to olivaceous or brownish yellow, convex, margin less. Epihymenium intense yellow-olivaceous, granular, K-, N-; spores (4-)5-7(-8) × (1-) 1.5-2 µm, oblong-ellipsoid. Photobiont *Trebouxia*-like algae. New York, Massachusetts, Maine, Minnesota, and Pennsylvania, Alberta, Saskatchewan, Ontario . . . . *P. lucida*

1. Thallus whitish to greenish. Apothecia not yellow **2**

2. Thallus C-, UV- (no lichen substances), white to pale greenish gray or yellowish green to dark green, granular, Apothecia dark brown to blue-black or sometimes livid blackish or reddish brown (shade form pale, blue-gray, gray-brown), convex to hemispherical, evenly distributed. Hymenium greenish to blue-greenish; epihymenium pale green to blue-green, olivaceous or greenish black, K+ greenish, N+ purple-red. Spores 4-7 × 1.2-2 um, tear-shaped or drop-shaped (oblong-ovoid). *United States*: New York, Washington, Ontario . . . . *P. clavulifera*

2. Thallus C+ red (gyrophoric and lecanoric acid) leprose. Apothecia pale, rose, dark brown, sometimes with a violet tint, convex to spherical, often agglomerated. Hymenium colourless to yellow; epihymenium pinkish or dark brown, K-, N-. Spores 4.5-6.5 (7) × 1.3-1.8 µm, tear-shaped or drop-shaped (oblong-ovoid). Also contains porphyrilic acid. Greenland. . . . . *P. leprosa*

Acknowledgments

I am grateful for the specimens sent to me on loan by Tom Nash (ASU). I would also like to thank Irwin Brodo for confirming all my identifications of the specimens and for his valuable comments on the manuscript.

Documents Cited (marked * in text)

Global Biodiversity Information Facility (GBIF). 2008 Epiphytic Lichen data supplied by G. Lettau at the Botanical Museum Berlin-Dahlem, Biologiezentrum Linz, UK National Biodiversity Network, Natural History Museum, University of Oslo, The Swedish Museum of Natural History (NRM), Botany (UPS), and Icelandic Institute of Natural History (Accessed through GBIF Data Portal, www.gbif.net, 2008-12-10)

Ryan, B. 1994-1999. Working keys for the identification of North American lichens. (Privately distributed, unpublished.)

Literature Cited

Brodo, I. M., S. D. Sharnoff, and **S. Sharnoff.** 2001. Lichens of North America. Yale University Press, New Haven, London. 795 pages..

Benesperi, R., G. Brunialti, A. Fappiano, L. Frati, P. Giordani, S. Loppi, S. Ravera, P. Buzio, C. Benco, S. Martellos, and **M. Tretiach.** 2007. Contributo alla conoscenza della flora lichenica dell'Abetone, Appennino Tosco-Emiliano. Informatore Botanico Italiano 39(1): 43-51.

Coppins, B. J., and **O. W. Purvis.** 1987. A review of *Psilolechia*. Lichenologist 19: 29-42.

Czarnota, P., and **M. Kukwa.** 2008. Contribution to the knowledge of some poorly known lichens in Poland.II. The genus *Psilolechia*. Folia Cryptog. Estonica 44: 9-15.

Flakus, A., M. Kukwa, and **P. Czarnota.** 2006. Some interesting records of lichenized and licheicolous Ascomycota from South America. Polish Botanical Journal 51(2): 209-215

Lowe, J. L. 1939. The genus *Lecidea* in the Adirondack Mountains of New York. Lloydia 2: 225-304.

Purvis, O. W., B. J. Coppins, D. L. Hawksworth, P. W. James, and **D. M. Moore.** 1992. The Lichen Flora of Great Britain and Ireland. The British Lichen Society, London.

Wirth, V. 1995. Die Flechten Baden-Württembergs, Teil 1 & 2. Ulmer, Stuttgart.

Wong, P. Y., and **I. M. Brodo.** 1992. The lichens of southern Ontario. Syllogeus 69: 1-79.

Received 13 October 2009
Accepted 23 June 2010

Book Reviews

Book Review Editor's Note: We are continuing to use the current currency codes. Thus Canadian dollars are CAD, U.S. dollars are USD, Euros are EUR, China Yuan Remimbi are CNY, Australian dollars are AUD and so on.

ZOOLOGY

Birds of Australia – 8th Edition

By Ken Simpson and Nicolas Day. 2010. Princeton University Press, 41 William Street, Princeton, New Jersey. 381 pages. 39.50 USD, Softcover.

I have been very impressed over the years with the Princeton Field Guides series. Each guide packs a lot of information into a relatively small package. This 8th edition of the *Birds of Australia* is no exception.

I have to confess that I have not been to Australia ¼ but I plan to go in the next few years, and this book will be in my carry-on baggage along with my binoculars. It has a durable waterproof cover and high quality paper, both of which should hold up well in the field.

Its organisational structure is similar to most field guides, starting with small sections on how to use the book and tips on bird observation. Some of the tips I don't recall seeing in any other guide, such as how diseases, light, staining and pollen all can affect plumage colours and thus, identification. I would have preferred to see these followed by the section (near the back of the book) on "vegetation and land form habitats," which includes concise descriptions of the various habitat terms used in the following species descriptions. Next is a "key to the families," which is useful, although the divisions between family, tribe and subfamily are given equal weight and might be confusing. The families are less clear in the main field information section of the book, where each page header indicates which families are represented there, but on multi-family pages it's not clear which species are in which family, as they are lumped together with no divisions.

The "field information" for each species is spare, using a combination of codes (abundance, movement, endemism) and brief text, which describes male, female and juvenile plumages, size, voice and habitat. A lot of information is also packed into the thumbnail-sized range maps, which show breeding and non-breeding ranges, areas of sparse records and migration trends. If there is more than one race, the map has a capital letter which corresponds to the name of the race, given below the map, and often referred to in the text. A close reading of the "codes used in this book" section will enable the reader to glean the most out of the information.

Between the text and the range map is usually an exquisite pen-and-ink drawing (over 900 in the book) that illustrates other plumages, closeups of confusing field marks, different races, flight patterns, behavioural postures (such as tail flick), or additional field marks. These are an excellent adjunct to the facing colour plates. The 132 plates illustrate both sexes and frequently show juveniles and different races also. Many of the plates also show similar species close together on the page for easy comparison, and many show the birds in typical habitat.

This "field information" section, which is the bulk of the book, covers residents and more frequent visitors, while 85 species of "vagrants, waifs, strays and overshoots" are covered in the following "vagrant bird bulletin." Here there are no facing colour plates, but small colour drawings are sandwiched between the field description and the distribution map.

The last extensive section covers "breeding information" in an interesting way, by giving a short description of the life cycle of a bird then a "breeding summary," which includes: courtship, nest description, number and description of eggs, length of incubation period and which sex incubates, hatchling and fledgling details, and parental care. This is followed by bar graphs showing the breeding season for each species within the family. My biggest quibble with the book is here. While grouped by family, the species sequence for the bar graphs is not the same as in the "field information," rather appearing to be random (not even alphabetical, which would have been useful). This is confusing and makes it hard to locate the species you are interested in. It would also be a simple matter to include page numbers beside each bar graph that would link back to the descriptions and colour plates.

For those birders who can afford to island hop or are building their life lists with island endemics, there is a short section on "Australian island territories checklists" which is organised by major oceanic island. A quibble here is that while Lord Howe Island is shown

on the introductory map, the others are not, although their geographic coordinates are listed in the checklists. For those not intimately familiar with South Pacific geography, a location map for these island territories would be helpful.

The first appendix covers "hints for birdwatchers" on equipment, legal issues, safety, birdcraft and bush-craft, and some excellent tips on "birdwatching in various habitats." These are followed by a short glossary, a list of birdwatching and naturalist organisations and a "core library" list. Finally, there are separate indices for Latin and common names, and a "quick index to field information."

All-in-all this is an excellent guide and I look forward to giving mine a good field test in the near future.

CYNDI M. SMITH

Box 5, Waterton Park, Alberta T0K 2M0 Canada

The Birds of Barbados

By P. A. Buckley, Edward B. Massiah, Maurice B. Hutt, Francine G. Buckley and Hazel F. Hutt. 2009. British Ornithologists' Union, P.O. Box 417, Peterborough, PE7 3FX UK. 295 pages. 40 GBP.

Barbados has long been a popular destination for Canadian sun seekers. But beautiful beaches and coral reefs aside, what does it have to offer the visiting birder? Being a small island it has limited species diversity — thirty species makes a good birding day — and only one endemic bird species, and that perhaps one of the dullest birds on the planet (the recently split Barbados Bullfinch). The answer lies in the wind, more precisely, the trade winds. The same winds that first blew European explorers to the Caribbean routinely transport Afro-eurasian vagrants to Barbados. This factor, coupled with its proximity to South America, makes it the "Scilly Islands" of the Americas, with a jaw-dropping list of vagrants and "firsts" for the Americas.

This rich record is amply documented in the latest instalment of the British Ornithological Union *Birds of...* series. In keeping with the rest of the series, it is a scholarly, extensively researched work; more than an annotated list, it is a comprehensive study of the island's avifauna, both resident and visiting. There is an extensive introductory section which describes the island's ecology and its history, including the accounts of early naturalists. There is an exhaustive discussion of the ecology of the island and its avifauna, touching on various species groupings (seabirds, shorebirds, land birds, etc.) and concepts (endemism, the role of migration and vagrancy, etc.) There are also 24 appendices touching on an extensive array of topics, everything from Christmas Bird Counts and ringing [banding] returns to the likely proximate geographical origins of the island's avifauna and Barbados bird holdings in major museum collections. There are particularly intriguing sections on "enigmatic historical taxa" and "historical apocrypha" which, in addition to expanding one's vocabulary, provide a fascinating glimpse into the past.

Like all works on regional avifauna the heart of the book is the systematic list, and this is where it shines. Each species receives a comprehensive treatment including a description of its range in the world and in the West Indies and, of course, its occurrence in Barbados. The latter includes the first known mention of the species, followed by an extensive discussion of its historical and present status. This account includes seasonal information such as the earliest arrival or latest departure dates for migratory species, along with a discussion on its breeding status on the island. For species which occur only rarely, details are provided for each sighting. Included in each account is the often evocative local name for the bird, if one exists. Most of the species accounts conclude with a comments section which may touch on a variety of subjects such as the taxonomic status of the bird or interesting ringing returns. The text is complemented by many tables, maps and colour plates, the latter including aerial photographs of various aspects of the island, photographs of some typical Bajan birds and a pot pourri of exciting vagrant species. The book ends with an extensive (20 page) list of references and a detailed index. It is worth highlighting that this is not a "where to go birding" book, nor is it a guide to identification, for that one must look elsewhere.

Despite being relatively slight, there is so much packed into this book that it is hard to navigate. This is not aided by a confusing format. For example, the annotated list starts only on page 76, and then only after a long annotated list of "unsupported" species. It should also be noted that the authors have taken a liberal approach to taxonomic questions, thus, "Golden Warbler" is treated as a full species, distinct from "American Yellow Warbler". While some may see this as jumping the taxonomic gun, it is useful for a regional work to delineate the occurrence of recognizable forms, recognizing that the consensus on species limits will ebb and flow over time.

The *Birds of Barbados* sets a new bar for Caribbean ornithology, and will be equally at home in a university ecology course or a birder's library. It is a fitting tribute to Maurice and Hazel Hutt, who passed away prior to its completion, and follows in the tradition of the venerable James Bond, author of the classic work on Caribbean birds. I would highly recommend this book to anyone with an interest in Caribbean ornithology and ecology.

MARK GAWN

25 Forsyth Lane, Ottawa, Ontario K2H 9H2 Canada

Nightjars, Potoos, Frogmouths, Oilbird, and Owlet-nightjars of the World

By Nigel Cleere. 2010. Princeton University Press 41 William Street, Princeton, New Jersey, USA. 464 pages. 45.00 USD, Cloth.

Before I review this book I would like to comment on this odd group of birds – the caprimulgids. For the most part their plumage is a mixture of browns and greys. Many have white throats, wing and tail spots. Most are similar in size and shape. The combination of colour and shape makes it very difficult to "see" these birds among dead leaves and branches where they live. I once spent 40 minutes getting a group to "see" a nighthawk asleep on a branch about 20 metres away and in clear view. The word used most often is cryptic – secret, tending to conceal or camouflage.

When you get to see one, these birds have an elegant, understated beauty in their soft brown feathers. Yet they are also odd. They look somewhat like owls, but are clearly not. They also look a little reptilian. They are nocturnal or crepuscular and this, coupled with their camouflage means they are rarely seen. I worked out in a typical year I go out birdwatching at night maybe two percent of the time. I see most local owl species [the other big group of nocturnal birds] most years because they can be found roosting in trees during the day. This year I have seen over two dozen owls so far of seven species, yet only one caprimulgid sleeping in a tree.

Depending on the source there are well over 100 species of caprimulgids, this book says 135. *Handbook of Birds of the World* lists 118. Comparing this book's list of species to other sources was difficult because the author has switched some groups of birds to new genera. For example, he has moved a large swatch of species from *Caprimulgus* to *Antrostomus*. He has also used different English names for several birds. Much of the difference in numbers is because this author recognizes several birds as full species whereas others still consider them subspecies [e.g. Little Nightjar, *Caprimulgus parvulus* and Todd's Nightjar, *Caprimulgus (parvulus) heterurus*] Of the species listed, five are only known from a single specimen. The calls of nine species are unknown. The eggs of twenty species are undescribed. Many have not been photographed in the wild. I doubt we have heard the end of the taxonomic convolutions of this perplexing family.

Finding a book that will improve my knowledge of these enigmatic creatures was therefore wonderful. The book starts with sections on distribution, general biology and taxonomy. Bulk of the book is devoted to individual species accounts and is followed a glossary, photo credits, the index etc. I found the introductory sections interesting and educational, well worth the read.

For the species section the author has collected the best photographs he could find. He has collected material from a large number of contributors, so the photo credits occupy 16 pages. Where no photos of live specimens exist he has used photos of museum specimens. All the photos of live, wild birds are really good quality. Presumably, if you find a bird that believes its camouflage is invincible it will sit for its portrait! These are accompanied by a small world map showing the locality and a large [quarter to half page] showing the bird's distribution. The distribution maps are excellent and so much easier to use than those in most other guides.

The text notes habitat, calls, breeding, status and a description. It is in this last section that this books shows a weakness. These look-alike birds call for an extremely detailed description like those used in shorebird guides. The identification notes are very short. For example the author states that a Lesser Nighthawk has "White band toward the wing tip" and a Common Nighthawk has "White band mid-wing." This is a critical field mark and this description is hardly as specific as it needs to be. Fortunately the flight photos of these birds clearly shows the slight, but discernable difference in this field mark. Most descriptions a similarly short.

In July this year the AOU split Whip-poor-will into the Eastern Whip-poor-will and the Mexican Whip-poor-will. The authors has anticipated this change and include them as separate species.

In addition to its value as an in formation source, I enjoyed re-visiting the photos. There are frogmouths with bad hair days and grumpy stares, potoos that look more like a branch than the real branch and quaint babies emerging as puffballs from a nearly invisible mother. All are quite delightful. This is a good, and fun, source book for avid naturalist. Now if I could only understand why the ancients called the birds goatsuckers in the weird belief that a pointed beaked bird would suck milk from tender parts of a goat.

ROY JOHN

2193 Emard Crescent, Ottawa, Ontario K1J 6K5 Canada

Raptors of New Mexico

Edited by Jean-Luc E. Cartron. University of New Mexico Press, 1312 Basehart Road, SE, Albuquerque, New Mexico, USA. 710 + xvi pages. 50.00 USD.

This six-pound, 726-page book – with 663 colour photographs – is both massive and sumptuous. As Richard L. Glinski says in his Foreword, it "sets a new standard for state and regional raptor books. Without doubt, it is the best one out there. … As an attractant, a visual aid, an educational display, a work of art, this

collection of photos is unmatched." Cartron, a French immigrant who abandoned a promising medical career in favour of raptor ornithology, has done a masterful work in compiling and presenting this landmark study, and is well supported by the observations and writings of thirty-seven contributing authors.

The nest photos and habitat photos are outstanding, with a full-page but not numbered photo at the start of each species account. Even non-birders will marvel and gush over the photos of nestlings, especially the Northern Saw-whet Owls and Boreal Owls; cuter and more appealing bird photographs are hard to imagine. Some photos of birds in the hand show special features to good advantage, even if a bit overdone for several common species including the Northern Goshawk and Harris's Hawk (6 each), Cooper's Hawk (5), Red-tailed Hawk and Northern Harrier (4 each) .

New Mexico, in area the fifth largest state in the USA, has extremely varied topography. The text and stunning photographs emphasize how steep-faced cliffs produce breeding sites for Prairie Falcons and Golden Eagles. Helpful maps display the main mountain ranges and rivers, the main urban centres and roads, the six main floristic zones, and eleven vegetation communities. The species accounts, for each of the 24 diurnal raptors and 13 species of owl, contain detailed maps, augmented by two additional maps of the American Kestrel and one of the Aplomado Falcon. Commendable is the use of question marks to mark areas, especially for the Zone-tailed Hawk and the Northern Saw-whet Owl, that require additional field work to confirm or reject whether breeding occurs. Appendices list museum egg sets of eight species of interest, and provide prey delivery rates and mark-recapture results for Flammulated Owls. A Glossary explains words that apply particularly to raptors.

Cartron occasionally uses long-outdated terminology. Most regrettable is his use of "returns," a term largely replaced by Mabel Gillespie in the initial issue of the journal *Bird-Banding* in 1930; Gillespie pointed out that "returns" should be used only for birds that *return* to be re-caught at or near the banding site in a year subsequent to their banding. "Recoveries" replaced it, but recent usage prefers this term for the terminal event, a dead bird. With the development of mist-netting and bal-chatri traps for capturing raptors alive, "encounter" is the best term for those still alive. Another shortcoming is the book's failure to name specific pesticides or biocides other than DDT. Monocrotophos, the cause of up to 20 000 Swainson's Hawk deaths in Argentina, is not named. Dieldrin is also not named, although in a referenced paper (Houston and Hodson 1997), it was the explanation for most Merlin mortality in Saskatchewan. The legend for Cooper's Hawk photograph 10.14 says "Copper's Hawk" and the final "ed" is omitted from Great Horned Owl on page 540. Regrettably, county names, used throughout the book, are present on only one map (M.2) and in tiny 6-point type, a detriment for older readers especially. The legend for map M.3 uses the word "towns" loosely to apply to the 29 cities, 11 towns, and a number of villages. The above flaws, however, are minor blemishes in a work of such beauty.

Cartron begins his book with a discussion of the first ornithologists to use the term "raptor" — Johann Illiger coined the term "raptatores" in 1811 and Nicholas Vigors in 1825 changed the name slightly to "raptores," — and Cartron ends on a positive note: "Birds of prey are doing better today than they were in the early and mid 20th century, when shooting and pesticides caused many raptor populations to plummet… raptor populations are at least fortunate enough to be regarded as ecologically important, charismatic, or simply enriching of people's lives."

This well-researched and superbly illustrated reference book belongs in University and college libraries, and will become a proud possession of many raptor enthusiasts. Contributions from 16 "sponsors" and three "collaborators" have helped to keep the sale price only a quarter to a half of what otherwise would have been the case. While its weight makes it inappropriate for reading in an automobile or aeroplane, or in bed, it will command a place of honour on a solid desk.

C. STUART HOUSTON

863 University Drive, Saskatoon Saskatchewan S7N 0J8 Canada

BOTANY

Carbon Sequestration and Transformation in Bamboo Forest Ecosystem

By Zhou Guomuo, Jiang Peikun and Xu Qiufang. Science Press, 2010. 216 pages. 60.00 CNY.

Bamboo is a group of most beautiful and useful woody plants belonging taxonomically to the subfamily Bambusoideae of the family of Gramineae. Bamboos are evergreen, monocotyledonous plants, and amazingly adapted to hundreds of different locations and climates. Most of bamboo species are relatively fast-growing (some species can even grow almost 4 feet a day), attaining stand maturity within around five years, but flowering infrequently. Like most other grasses, bamboos grow and flourish until they are ready to flower; then they produce seeds and die. Bamboos produce primary shoots without any later secondary growth, and usually spreads by horizontal, multi-culmed rhizomes.

Bamboo has been used by about 2.5 billion people, mostly for fibre, food and for handicrafts and building material, or for providing aesthetic and functional purposes to create good landscapes, especially in Asia, for thousands of years. Yet, its potential contribution to sustainable natural resource management has not been specially stressed. Bamboos are very important plants, both ecologically and economically. Bamboo forest is considered one of the best renewable resources on the planet, and is a sustainably-used resource once established. Its biological characteristics make it a perfect tool for solving many environmental problems, such as soil erosion control, water purification and conservation, carbon sequestration, recreation and so on.

Compared with other tall flowering plants, the pattern of bamboo growth may give an impression of high productivity, however, in fact, sometimes the "rapid growth" is a process of re-distribution of previously stored reserves. The entire bamboo sub-family have C3 photosynthesis lacking the C4 pathway and anatomy, thus the maximum possible productivity of bamboos is theoretically unlikely to be very high. Furthermore, the growth rate of bamboo is dependent on local habitat quality and climatic conditions.

Understanding the ecology of bamboo is unquestionably important, especially under the present global background of advocating low carbon economy and the potentially large ecological restoration works in many degraded tropical and subtropical areas, yet, so far, literature on the ecology of natural bamboo stands is meagre, and reports from plantation stands are rare. Bamboo has been neglected or ignored in the past by tropical foresters, who tend to concentrate on timber trees. Bamboo may have potential as a bioenergy or fiber crop, although some reports of its high productivity seem to be exaggerated. So far, literature on bamboo productivity is scarce, with most scattered reports coming from various parts of some Asian countries. Most bamboo currently has not been used scientifically and sustainably, since the rate of harvest from forest stands usually exceeds that of natural growth, and since the users usually do not have sufficient knowledge.

Bamboo resources in China are most abundant in the world. China is one of the earliest countries using the bamboo resources. It has long been the important forest resources in tropical and subtropical regions of China. According to the 6th National Forest Resource Inventory of China, the present bamboo forest area in China is about 500 million ha, accounting for 2.5% of forest area of China, and 39% of the total area of bamboo of the world. There are 38 genera and 500 species of bamboo plant species in China, accounting for 36% and 39% of the bamboo species of the world, respectively. Various aspects of bamboo have been studied in China relatively early and for the long-term, yet, these research results have not been summarized over time. The publication of the book Carbon Sequestration and Transformation in Bamboo Forest Ecosystem meets such a demand. The book is mainly based on the authors' research data in Zhejiang Province.

The book is divided into two parts. The first part reviews the main previous research results on carbon fixation and transformation in bamboo forest ecosystems. The second part is divided into 11 chapters. Chapter 1 summarizes the latest progresses in research on the carbon pool, carbon cycle, and carbon balance of forest ecosystems; Chapter 2 summarizes progress in research on the cultivation, management and biomass of bamboo; Chapter 3 and 4 deal with the spatial distribution of bamboo forests, and estimate the total biomass and carbon storage of bamboo in Zhejiang Province; Chapter 5 and 6 reveal the carbon accumulation and dynamics of bamboo forest with different management modes and different ages; Chapter 7 analyses the impacts of fertilization and floor cover on the evolution of soil organic carbon in bamboo forests; Chapter 8 compares soil active organic carbon pool of bamboo forests in subtropical area with those of other forest stands; Chapter 9 discusses and compares the abilities of soil carbon sequestration of bamboo, fir, and pine forests; Chapter 10 analyses the impacts of floor cover in winter on the rates of soil respiration in bamboo forests; Chapter 11 summarizes the main results of the present research on carbon fixation and transformation in bamboo forest ecosystems.

This book is suitable for scientists, teachers, students or other persons who are engaged in or interested in forest science, ecological science, soil science and relevant fields.

LI DEZHI[1] AND QIN AILI[2]

[1] Lab of Urbanization and Ecological Restoration of Shanghai; National Field Observation and Research Station in Tiantong Forest Ecosystem of Zhejiang; Department of Environmental Science, East China Normal University, 3663, Zhongshan Rd (N). Shanghai, China. 200062

[2] Shanghai Vocational and Technical College of Agriculture and Forestry, 658 Zhongshan 2 Road, Songjiang, Shanghai, China. 201600

Pitcher Plants of the Old World

By Stewart McPherson, 2009. Redfern Natural History Productions, 61 Lake Drive, Hamworthy, Poole, Dorset BH15 4LR, England, UK. xiii + 631 pages. (Volume 1); 768 pages (Volume 2). £34.99 ($79.99) per volume plus shipping. Cloth.

Pitcher plants are intriguing in term of not only unusual forms, but also unique ways of nutrient acquisition. Pitcher plants include the largest and most spectacular of all carnivorous plants. They produce highly specialized foliage that takes the form of hollow, liquid-filled "pitchers", forming the extraordinary prey-trapping mechanism to lure and prey upon insects, arthropods and other small animals. Contrast to most

plants absorbing nutrients from the soil through their roots, carnivorous plants absorb nutrients from their animal prey through their leaves specially modified as traps. By trapping and digesting various invertebrates, and occasionally even small frogs and mammals, these plants whose most common habitat is in bogs and fens, where nutrient concentrations are low but water and sunshine seasonally abundant, can obtain some nutrients, thus they have the most bizarre adaptation strategies to unfavourable conditions, mostly low nutrient availability in wet, acid soils.

The carnivorous habit evolved independently in many plant lineages. In the Old World, there are two genera (families) of pitcher plants, i.e. Nepenthes and Cephalotus. Nepenthes occur across tropical areas of the western hemisphere, mainly in Southeast Asia, and consists of 120 species, including the largest of all carnivorous plant species which produce giant "pitcher" traps. Species of Nepenthes differs in the shape, size and colouration of its pitchers. Cephalotus grows only in Southeast Australia and produces small, purple pitchers the size of a thimble which are specialised towards the trapping of small prey.

Pitcher plants usually grow in harsh habitats which are usually inaccessible to humans. Thus, so far the knowledge about pitcher plants is not adequate. The newly published book Pitcher Plants of the Old World is up to date the most comprehensive overview and dependable and important reference book on pitcher plants of the Old World, and also the only publication dealing with the genus Nepenthes throughout its geographical range. The two volumes summarise the author's three-year research in the field. This 1399 page work contains 751 spectacular images. 120 species of *Nepenthes*, plus 5 incompletely diagnosed taxa are recognised, along with *Cephalotus follicularis*. Several species documented in this work have been discovered only very recently and, over 30 species have their photos published for the first time. All species in both genera of *Nepenthes* and *Cephalotus* of Old World are introduced in terms of the biology, ecology, diversity, distribution and conservation status and the various threats and practical means of conservation of every known species for the first time in detail, and also importantly high quality photographs illustrating the habitat, habit and pitchers (including forms on different parts of the plant where appropriate) are provided, These were taken by the author during 18 months of intensive and challenging fieldwork over a three-year period. The author also pays plenty of attention to the trapping mechanism and mutualistic fauna which inhabit trapping pitchers. Colour variants of the pitchers of many species are also illustrated. Cephalotus is treated in similar depth and, like Nepenthes, is illustrated with approximately 30 photographs, line drawings etc. Currently, many pitcher plant species are not in cultivation, and also there is often confusion among species, the author studied in detail, and photographed each species of Nepenthes and Cephalotus in the wild. This documentation has filled the lack of available information on these species, and is therefore of great scientific values.

At least some species of pitcher plants are on the verge of extinction in the wild, and some of them may have completely disappeared. The distribution of dozens of pitcher plant species usually are very limited, and sometimes the wild population may consist of just a few hundred plants. Furthermore they are faced with the serious risks of being poached, over-collected or having their habitat destroyed. The extraordinary value of these plants or the high horticultural interest made these risks even greater. It is highly likely that several species may become extinct over the next few years in the wild, if any ex situ or in situ conservation measures are not taken. The author's enthusiasm for the conservation and his commitment to habitat and ex situ conservation are shown throughout the two volumes, and some of the advice given. He also provides coverage of issues which seriously threaten the survival of many Nepenthes species, as well as information on cultivation of various species (highland Nepenthes are notoriously tricky to keep alive, even among those for whom carnivorous plants are more an obsession than a hobby).

Pitcher Plants of the Old World (Volume One) consists of the following chapters; Introduction, Carnivorous Plants of the World, The Pitcher Plants of the Old World, The Evolution of the Pitcher Plants of the Old World, Trapping Processes, Infauna, *Nepenthes* of Borneo and *Nepenthes* of Peninsular Malaysia and Indochina. Pitcher Plants of the Old World (Volume Two) comprises *Nepenthes* of the Philippines, *Nepenthes* of Sumatra and Java, *Nepenthes* of Sulawesi, *Nepenthes* of New Guinea and the Maluku Islands, *Nepenthes* of the Outlying Areas, *Nepenthes* Hybrids, *Cephalotus follicularis*, Habitat Loss and the Threat of Extinction and Cultivation and Horticulture, Appendix, Glossary, Bibliography, Index. The chapter on cultivation and horticulture provides historical information and up to date details on the conditions required to grow Nepenthes and Cephalotus successfully.

It is an excellent work to be enjoyed by plant enthusiasts and professional botanists in general, and is an essential book for carnivorous plant enthusiasts in particular.

LI DEZHI[1] AND QIN AILI[2]

[1] Lab of Urbanization and Ecological Restoration of Shanghai; National Field Observation and Research Station in Tiantong Forest Ecosystem of Zhejiang; Department of Environmental Science, East China Normal University, 3663, Zhongshan Road (N), Shanghai, China. 200062

[2] Shanghai Vocational and Technical College of Agriculture and Forestry, 658 Zhongshan 2 Road, Songjiang, Shanghai, China. 201600

ENVIRONMENT

Essentials of Conservation Biology (Fifth Edition)

By Richard B. Primack. 2010. Sinauer Associates, Inc., 23 Plumtree Road, Sunderland, Massachusetts, 01375 USA. 538 pages. 86.95 USD.

Richard Primack's textbook has long provided a comprehensive introduction to the major concepts and problems facing the ever-changing field of conservation biology. This fifth edition, which coincides with the United Nations' International Year of Biodiversity, continues to serve as a detailed guide for students and professionals. In addition to updated full-colour illustrations and detailed photographs, summary statements of major points have been added to the text margins, to provide useful study aids for students of the subject. *Essentials of Conservation Biology* is also highly useful as a supplemental text for students of general biology, ecology, wildlife biology and environmental policy courses.

In the preface, Primack himself acknowledges the increase in public interest and awareness of conservation issues, and the subsequent emergence of conservation biology as a scientific discipline. In updating *Essentials* he has placed an emphasis on the role that scientists, the general public, governments and conservation organizations must play in addressing the loss of biodiversity. He draws from biological theory, in addition to applied research, in order to explain the connections between education, law, social sciences and the rapidly advancing area of environmental economics. The very latest advances in biological knowledge are combined with information regarding new practical approaches to conservation. The text presents all of this information in a clear, non-technical language that will not confuse newcomers to biology, without patronizing the biological and environmental professionals to whom the book is also directed.

Essentials is separated into five main parts; each addressing different aspects and approaches to the discipline. The first part starts at the beginning: by establishing the meaning of conservation biology and how this relatively new discipline emerged as a science. Key ecological ideas relating to biological diversity are subsequently presented, such as succession and species interactions. He also describes the main levels at which biological diversity can occur: species, genetic and ecosystem. These chapters are particularly useful in fulfilling the author's objective of providing a text to complement other areas of natural science. They also provide an excellent foundation for non-biologists interested in conservation.

The next part deals with putting a value on biological diversity. Given the necessity to obtain funding, backing and support in order to propel conservation work, putting a comparable value on our existing wildlife and habitats in becoming all the more important. Biologists such as myself, often need guidance and simple explanations of how to utilize the blossoming field of ecological economics, and Primack certainly provides this. Direct use values, indirect use values and ethical values are explained, supported by highly relevant case studies.

Part III, detailing the threats to biological diversity, puts the "current, human-caused mass extinction" into context by comparing current extinction rates with past mass extinctions. Vulnerability to extinction is explained within the contexts of endemic species and designated conservation categories. The text then goes on look at habitat destruction, fragmentation and degradation, by examining the causes and effects of these actions. The effects of global climate change are also described, with particular reference to the effects upon plants, sea levels and water temperatures. This often contentious topic, which has a tendency in recent years to overshadow other environmental issues in the media, and scientific literature is discussed in an admirable manner; presenting the evidence and concentrating on the potentially devastating effects upon biological diversity. This part of the book is completed by looking at overexploitation of natural resources, the impacts of invasive species and the effects of disease.

Population and species level conservation is discussed in Part IV. Again the format of presenting the problems, followed by the potential and current solutions, is employed. Issues facing small populations are described, utilizing rhino species of Asia and Africa as a poignant case study, and making links with the threats to biodiversity discussed in the previous sections. A chapter examining applied population biology leads on nicely to the next, which deals with establishing new populations. The final chapter in this section looks at ex-situ conservation strategies, again providing examples highlighting how conservation biology is currently being used.

The penultimate part investigates further practical applications, but at the habitat and ecosystem levels. The ecology behind protected areas, reserve design and habitat connectivity is clearly presented. Primack goes on to talk about managing protected areas, in addition to conservation outside reserves, such as in urban and agricultural areas. The text continues to embrace conservation as a modern discipline by looking at the emerging area of restoration ecology. Dealing with a particular interest of mine, the author has done well in explaining how ecological principles can be applied to projects that are restoring and improving land which has been degraded, often by human activity.

The final section does an excellent job of detailing the role of human societies in conserving biological

diversity. The functions of legislation, agreements and funding sources are all discussed. These are often alien topics to even the most well-read of natural science students, and the author does well to link their uses to the activities discussed previously in the book. Finally, an agenda for the future is presented, reinforcing the ongoing problems and possible solutions, whilst describing the role that conservation biologists have to play in all this.

Essentials of Conservation Biology provides everything you could want from a textbook on the subject. Descriptions are clear and unpretentious, and the language is suitable for people from all backgrounds. Full-colour photographs and illustrations complement the text, whilst graphs and tables clearly show useful data. The text covers a variety of topics, providing an excellent background for non-biologists. Summary and discussion points at the end of each chapter provide direct conclusions, in addition to areas for debate. Well chosen case-studies add substance to the text and help to prove that conservation biology is very much a practical science, based upon basic ecological theories. Primack himself encourages a hands-on approach for aspiring conservationists and advises readers to make contact with organizations that he references in the Appendix.

The author claims that he has intended to provide the reader with "a greater appreciation of the goals, methods and importance of conservation biology". I feel that he has certainly done this and more, in a clear and detailed manner.

MATTTHEW ILES

1431 Lakeshore Road, Apartment 308, Burlington, Ontario L7S 1B4

The Game of Conservation – International Treaties to Protect the World's Migratory Animals

By Mark Cioc. 2009. Ohio University Press, 88 University Terrace, Scott Quadrangle, Athens, Ohio 45701. 267 pages. 24.95 USD.

Migration is one of the great wonders of the natural world. One important thing uniting all migratory species is the fight to survive. Migration as a large-scale movement enables animal populations to spend their life in two or more different areas, usually because lack of food makes them impossible to stay in the same place. Other reasons for animals migrating might be to find essential minerals, shelter or to avoid harsh winter weather, to search for a mate, to give birth, lay eggs or raise young, to moult in a safe place, or to flee overcrowded conditions, and so on. Migratory species are in many ways more vulnerable as they use multiple habitats and sites and a wide suite of resources throughout their migratory cycle. The growing array of threats faced by them may include habitat destruction or fragmentation, overexploitation, forcing changes in migration routes, disrupting food sources, affecting nesting and breeding habits and increasing susceptibility to diseases, and global climate change will tend to impose further threats. The decline of migratory species is by no means a new problem. Saving the great migrations will be one of the most difficult conservation challenges of the 21st century, but failing to do so timely will cost heavily, ecologically and even economically.

To carry out conservation, measures such as maintaining a coherent network of stopover sites, creating and expanding suitable habitat and developing and sustaining trans-boundary corridors that allow species to migrate as the environmental changes should be taken. However, protecting animal migrations has been very unsuccessful since that conserving migratory animals poses some unique challenges, one of which is the efficient international coordination for such conservation.

Migration over long distances means crossing many international borders and entering different political areas with their own environmental policies, legislation and conservation measures. Thus, the management of migratory species with a multinational home-range need efficient international cooperation between governments, NGOs and other stakeholders along the whole route of a species to share knowledge and to coordinate conservation efforts. This is especially true for the endangered animal species, with so few individual survivors that the species could soon become extinct over all or most of its natural range, and for the threatened species, still abundant in their natural range but declining in numbers and likely to become endangered.

Traditionally, legislation on wildlife focussed on protected areas and hunting restrictions (e.g., protection of listed species), and has rarely adopted a comprehensive approach to wildlife management. Twentieth-century nature conservation treaties often originated as attempts to regulate the pace of killing rather than as attempts to protect animal habitat. All of these treaties are still in effect today, and all continue to influence nature-protection efforts around the globe. The treaties had many defects, yet they also served the goal of conservation to good effect, often saving key species from complete extermination and sometimes keeping the population numbers at viable levels. Recent wildlife laws contain important innovations.

The recently published book of The Game of Conservation is a readable examination of nature protection around the world. It introduces the handful of treaties (all designed to protect the world's most commercially important migratory species) that have largely shaped the contours of global nature conservation over the past

century. The scope of the book ranges from the African savannahs and the skies of North America to the frigid waters of the Antarctic. The book also argues that the major animal-protection treaties of the early 20th century are better understood as international hunting treaties rather than as conservation treaties. These treaties were more concerned with the protection of hunting grounds and prized prey than with protecting habitats or ecosystems. The author described the formation and implementation of these treaties, as well as the efforts of conservationists and others to reform them and eventually institute new accords that would overcome the hunting ethos of the early treaties.

This book would be a good reference for the persons who are engaged in conservation ecology, population or ecosystem ecology, or environmental law or policy makers, etc., or any other persons who are interested in this field.

LI DEZHI[1] AND QIN AILI[2]

[1] Lab of Urbanization and Ecological Restoration of Shanghai; National Field Observation and Research Station in Tiantong Forest Ecosystem of Zhejiang; Department of Environmental Science, East China Normal University, 3663, Zhongshan Road (N), Shanghai, China. 200062

[2] Shanghai Vocational and Technical College of Agriculture and Forestry, 658 Zhongshan 2 Road, Songjiang, Shanghai, China. 201600

MISCELLANEOUS

The Ptarmigan's Dilemma: An Exploration Into How Life Organizes and Supports Itself

By John and Mary Theberge, 2010. McClelland and Stewart, 75 Sherbourne Street, Toronto, Ontario M5A 2P9 Canada. 401 pages. 34.99 CAD, Paper.

This is a remarkable book. It chronicles the professional life of a husband and wife team who, with their students, have conducted field studies for over 40 years and now have spent 6 years in putting it all together in this book. The subjects of their work included a wide range of species involving foxes, wolves, pikas, ptarmigan, ruffed grouse, caribou, white-tailed deer in various settings across Canada. The breadth of detailed studies were enhanced by many eco-tours in the Arctic, USA, Africa, Antarctic and Central/South America. It is an exceptional story, as they have followed through on many tasks in a very focussed way and applied seemingly boundless energies to often difficult projects. In so doing, John and Mary Theberge have come full circle, in not only spending their time in the field, but also effectively publishing their findings in scientific journals, taught university ecology courses and have been in the front lines in battles to protect the natural world. But this book is more then just a review of events and achievements; it is a scholarly account on how nature evolves and renews itself. A precedent had been set by a series of similar books, most notably in recent years in the book by Richard Dawkins entitled " The Greatest Show on Earth – The evidence for Evolution".

I found the title " The Ptarmigan's Dilemma" somewhat misleading. John Theberge did write his PhD. about ptarmigan, and in the course of that work found out that ptarmigan mysteriously grew gallbladders to cope with the birds' artificially manipulated diet. That anecdote comes early in the book. Very much later the authors inform us that the real dilemma that these grouse face is whether it is evolutionarily more rewarding for the survival of ptarmigan to leave the security of cover under the hens, or face potentially lethal low temperatures to obtain food. The point is, evolutionarily speaking, there are always tradeoffs. Natural selection does the rest. That is not a dilemma – it is the natural selection pressures that operate in all situations – Charles Darwin told us that a long time ago. Possibly "The healing hands of nature and mankind's role in destroying it" might have been a better title. Nevertheless, title aside, the authors have cleverly tied their vast experiences with what is known about the broader concept of evolution, genetic variability, natural selection, epigenetic inheritance, Darwinism, and Lamarckism. All concepts are well supported with appropriate citations. They cite important scientific papers, mixed in with anecdotal experiences, graduate students (their students only) projects and serendipitous findings, as occasions permitted.

The authors explore the notion that external factors may have a greater impact on the speed of evolution than mere natural selection as derived from Darwinian Theory. It leaves the reader with the hope that all is not lost in the bigger scheme of things and as such might be considered a relief from the "gloom and doom" themes outlined by many authors, when discussing the multi-faceted problems of our current biodiversity crisis, worldwide. I find little comfort in knowing that it will take between 3.3 to 5.5 billion years to create a new species of bird to replace the many of those that now have found themselves on the IUCN's (International Union for Conservation) endangered species list. I suppose a gloom and "doom" message does little to attraction the attention of our next generation of nature enthusiasts.

Not only species ,but systems in which they thrive, are dealt with in this book. I learned, with great interest, about the specifics of dynamics relating to phenomena which are common knowledge but only in a general way. For example, why the modern population explosion of Snow Geese in North America? What are the reasons for mass concentrations of Sandhill Cranes

along the Platte River in Nebraska? There is an eloquent discussion about the plight of the Palouse prairie in western North America. Every ecologist should read about the author's reflections on the merits of observation based science (page 223) vs. the more modern fashionable view on experimental science to get answers to biological questions.

Rarely is there a tome that is completely devoid of shortcomings. To keep the reader's attention there are, at times, lapses of objectivity in this book. "Fetid odour of bison dung" and "red-rimmed beady eyes" of a bison bull is not something you will experience in Canada's Wood Buffalo National Park. Nor will a bull bring his "head up, and then look around searching for wolves that might mean danger". There are errors in spelling of place names and of people in the book, but these are not major shortcomings of the book. The authors have brought their world (our world) to us, and it was therefore their responsibility to capture the readers attention. In the process a bit of hyperbole is acceptable, if that is what it takes to get the job done. Hardcore science can be boring and not entertaining. The authors' have not abandoned objectivity for clarity to deal with complex subjects. This work is written in an engaging prose, covers a broad subject and is a powerfully strong, scholarly piece of work. If only more biologists would take the time to write about the "life and times" during their professional careers in such a profound way. Future biologists will benefit from those who have come before, and they in turn should place their messages into the bigger scheme of things – how can we make this a better place for future generations? Understanding the functional relationships and processes in nature is a way of setting future agendas and apply new techniques to resolving environmental management issues. I applaud the Theberges for a job well done!

LU CARBYN

137 Wolf Willow Crescent, Edmonton Alberta T5T 1T1 Canada

[**Book Review Editor's note:** This book was a finalist for the Writers Trust Literary Prize for Non Fiction 2009-10].

The Practical Naturalist: Explore the Wonders of the Natural World

Dorling Kindersley Ltd. DK Publishing (United States), 375 Hudson Street, New York, New York. 255 pages. 22.95 CAD, Paper.

This book is interesting in concept and appealing in delivery. However, I encountered several problems while reading it. I am concerned that some of the information presented is confusing and imprecise. Reading it reminds me of reading the newspaper. If I know the subject well, I notice if the story is expressed unclearly or incorrectly. If I don't know the subject well, I might not notice, but am left suspecting that many news stories haven't got the details exactly right.

It is a very attractive-looking book. I congratulate the designers on an eye-catching cover and a comfortably-sized volume with an accessible, friendly interior. The book presents the budding "practical naturalist" with a gallery of different landscapes, ecosystems and environments to explore, a hint at the range of beings and relationships found there, and tools and skills to help one along. It includes activity suggestions. These sections are well-organized and lavishly illustrated with drawings and photos in the typical Dorling Kindersley (DK) style. You are reminded that you can explore nature in your own house and backyard, but that there is a great big world out there full of wonderful stuff too. I believe the book could be truly educational and inspiring for an audience ranging from older children to adults.

Unfortunately, I ran into trouble by page 10. Early sections discussing "Nature of the planet" (page 10) and "Climate and seasons" (page 20) attempt to show global biomes and climatic regions on world maps. These maps are cartographically murky. The "Mature of the planet" page suggests readers find their own biome on a world map. I attempted that, to find that Lake Superior and Lake Huron drain directly into a river that flows to the Atlantic Ocean. Lakes Ontario and Erie are detached and landlocked to the south. The easternmost point of North America, which should be the Avalon Peninsula of Newfoundland and Labrador, appears far south of the Great Lakes. The climate zones map shows the sub-arctic zone extending well south of the Canada-United States border judging by where the Great Lakes are on the first map. I can't make sense of the arctic coastline which is also different on each map. There is something fishy about Sweden too. Is it really all "temperate forest" from north to south while Norway and Finland are "coniferous forest"? Maybe the maps are simply meant to be impressionistic. If so, it might have been wiser not to send readers on the doubtful trail of pinpointing their home biome.

I tried to set aside my frustration over the maps to move on to the rest of the book. I was tripped up again at the "Forest birds" spread on pages 98 and 99. I suspect the publisher was trying to adapt a European-focused book to market further afield. I wonder if the editors took enough care to make sure the book would honestly satisfy an audience outside of Europe. Consider this: The jackdaw "is widespread in most of the Northern Hemisphere." This makes me think the jack-

daw should be common in North America. It is absent, except as an occasional vagrant on the east coast. It might be widespread over half of the Northern Hemisphere, but not this half.

Here is another example from the same section: "Northern parula (is) a summer visitor to northeastern USA". Ahem. It comes to Canada too. Okay, that sort of omission is nothing new. But why not mention the important fact that the species breeds where it spends the summer? It wouldn't be such a problem if "summer visitor" appeared in the glossary at the back of the book, but it doesn't. Also on that page, the European species wood warbler is called both a "summer migrant" and a "visitor" in the broadleaf woods of Britain and Europe. It's true, these species spend significant parts of their lives in different parts of the world, but to me both "summer migrant" and "visitor" imply that the species is not breeding in the location.

Speaking of wood-warblers, again on the same page the authors also refer to North American "wood-warblers". Then we read: "The robin, found widely throughout Europe ..." and then, "American robins have several call notes ..." The authors might have chosen less confusingly-named species. It seems troublesome to use robins and robins, and wood warblers and wood-warblers, as examples on the same page without explaining how distantly-related species have similar common names in different parts of the world. The "Garden birds" section on pages 56-59 is more cleverly written and avoids this sort of problem.

Do these details matter? I think they do. (The coral snake – milk snake illustration of mimicry on page 12 has me baffled.) I also find it intensely frustrating that, for many of the species used as examples, there is no indication of from what part of the world they come. If that small detail were added I would feel much more satisfied. For instance, the "Water birds" spread on pages 144-145 includes the broad, geographic distribution for all the species used. I'm glad at least some of the authors thought that would be helpful.

Although I remain wary of the content, here is a selection of other sections that could delight and intrigue a budding naturalist: The diversity of life (although not a single micro-organism is mentioned); astronomy; a naturalist's toolkit and record keeping; what to wear and how to be safe; Forests (forest floor, logs, rot and recycling, the canopy, bark, fungi, the seasons); Tropical forests; Scrublands and heath; Grasslands; Mountains; Deserts; Caves; Cliffs; The polar regions; freshwater and marine ecosystems.

As a teenager I would have been excited to receive this book. It's sufficiently engaging to convince me to grab my naturalist's toolkit and run right out there. I'll have to leave it to the reader to decide if the captivating treatment of the book's broad concepts makes up for the content concerns. I would have loved to pass it on to the youngsters in my life, but I am reluctant to do that.

While DK is the publisher, the book also bears the National Audubon Society logo. An Audubon staff biologist is listed as a consultant and wrote the foreword. The publisher lists 26 different editors, contributors and others.

BEV MCBRIDE

574 Tweedsmuir Avenue, Ottawa, Ontario K1Z 5P2 Canada

ELECTRONIC SYSTEMS: WEB SITES

Feather Atlas http://www.lab.fws.gov/featheratlas/index.php

All of us have found a feather and wondered species it came from. Now you can get help from the U.S. Fish & Wildlife Service's feather atlas website that will help feather identification. It consists of high-resolution scans of flight feathers of a selected group of birds. As this is an ongoing project the authors plan to continually add new species. So far there are samples for hawks, ducks, pigeons, nighthawks, crows, cuckoos, owls, pelicans, gulls, grouse, flamingos and woodpeckers.

The scans are of museum specimens and illustrate the dorsal surfaces of 12 wing flight feathers or remiges and six tail feathers or rectrices [from the right half of the tail]. If the species is sexually dimorphic then there are illustrations of male and female feathers as well as juveniles where appropriate. A data table of total feather lengths and vane lengths is also included. This site does not illustrate feathers the body of the bird (these are usually soft, and have soft fluff at the base).

There are three ways to search and I tried them all. They worked well and were easy to use. I thought the "Identify a Feather" search the most interesting. You can pick from 8 basic patterns and 10 colours as your search variables. This will get you a page of potential candidates for you to examine. For example, selecting "unpatterned" and "pink" will bring up a choice of Roseate Spoonbill and Greater Flamingo. Similarly "barred" and "grey" will result in a choice of 8 birds. Once you decide on the closest match you can jump to the species page.

I think this will be a very useful page for anyone who looks for wildlife. However I do have one problem, the main page states that all species of native North American migratory birds are protected by the Migratory Bird Treaty and the possession of feathers is prohibited. So if you bring the feather home to identify it you are breaking US law!

ROY JOHN

2193 Emard Crescent, Ottawa, Ontario K1J 6K5 Canada

DENDROICA – An Aid to Identifying North American Birds

In May 2010 three Government agencies Environment Canada, CONABIO and the USGS launched a new bird identification website, Dendroica. Environment Canada is a Canadian agency charged with protecting the environment, conserving the country's natural heritage and providing weather and environmental predictions. CONABIO [Comisión nacional para el conocimiento y uso de la biodiversidad or National Commission for the Knowledge and Use of Biodiversity is a permanent inter-ministerial commission of the Federal Mexican government. Established to coordinate, support and undertake projects related to biodiversity within Mexico and the surrounding region. The USGS [U.S. Geological Survey] is a civilian mapping agency in the natural sciences [water, earth, and biological science] The USGS collects, monitors, analyzes, and provides scientific understanding about natural resource conditions, issues, and problems.

The new site is at http://www.natureinstruct.org/dendroica/ and you must register to be able to use the site. Registration is free and simple, requiring a minimum of information. Once you have received your password it is easy to access the site. Clicking on the Canada bar I reached a list of 436 species. This is far short of the 630 recorded in Canada. As the default setting excludes the rare and non-breeding birds I later changed the filter to include to these. This adds in the likes of Phainopepla and White Wagtail and raised list to 569.

I started by using the default settings. As I was about to visit Calgary, I decided to scroll to Baird's Sparrow. This took me to a page that had four examples of songs, four photos and a range map. By clicking on each song button I heard about ten to sixty seconds of song. The range map is full screen and depicts all of America, north and south. I next tried Brewer's Sparrow that carried 10 songs, three images and a map.

Scrolling through the birds listed it is easy to see that it primarily nesting birds, not visitors. For example, Leach's Storm-Petrel is included but not Wilson's Storm-Petrel [a common summer visitor]. However, the Siberian Tit, recorded as a rare nester in the Northern Yukon, is not on the list. Ross's Gull is listed and has a small dot, indicating breeding, at Churchill, MB, where the current yearly breeding status is unclear. There is no mark to show breeding at Penny Strait in Nunavut.

After I changed to include the rarities and visitors Wilson's Storm-Petrel was added, but the Siberian Tit was still missing, Similarly there is a page for Mew Gull but no entry for Common Gull. It was obvious that many rarities were missing from albatross [A Yellow-nosed Albatross was recently found at Kingston, Ontario, and I have seen several Black-footed Albatross off British Columbia] to Brambling. The list does contain introduced birds from Mountain Quail to European Goldfinch.

How good is the site? First, it is an easy site to use and the response to changes is very rapid. I found the examples of songs to be excellent. All the ones I tried were technically clear and gave a good representation of the variety of song types. The photos ranged from good to fabulous, with most being very good. The range maps were fine and I could scroll in to get better detail for Canada. There is no text so there is no indication that Eskimo Curlew is extinct, for example.

This a site in development so there are quite a number of inconsistencies. Many pages have items missing. For example, there is no photo or range map for Bar-tailed Godwit or Temminck's Stint, no songs for Little Gull and no map for Sooty Grouse. These are to be expected in a young site and I am sure will change. If you have good photos of Bar-tailed Godwit, Temminck's Stint or any of those missing you can get them added, with credit.

There are some odd discrepancies that are harder to fathom. The Little Gull range map entry shows it as resident on both coasts but no nesting sites, but Black-headed Gull page is correct. For Rock Pigeon, European Starling, House Sparrow, Eurasian Collared Dove, Grey Partridge, and Pheasant there is a range map, but it is blank. However the Chukar map is fine. The Mute Swan range map shows only Michigan and Illinois and not eastern NA, where it is so abundant that at least one state has initiated a cull. But the biggest irregularity is the photo of Sharp-tailed Sandpiper in the Stilt Sandpiper group and the Sharp-tailed Sandpiper section shows pictures of Stilt Sandpipers, but no Sharp-tail!

Despite these deficits I thought this site was very useful. For my purpose [reviewing some Alberta birds] I found it slightly easier to work with the filters on. It has more examples of song than the Cornell Lab site [http://www.allaboutbirds.org/guide/search] and more [better?] photos and is slightly easier to use. I believe this will be my new "go-to" site, particularly for song. I am certain it will only get better.

ROY JOHN

2193 Emard Crescent, Ottawa, Ontario K1J 6K5 Canada

NEW TITLES

Prepared by Roy John

† Available for review * Assigned
Currency Codes – CAD Canadian Dollars, USD U.S. Dollars, EUR Euros, AUD Australian Dollars.

Amphibians & Reptiles of British Columbia. By B. Matsuda, D. Green and P. Gregory. 2010. Royal British Columbia Museum, 675 Belleville Street, Victoria, British Columbia V8W 9W2. 272 pages. 25.95 CAD.

† **Identifying and Feeding Birds.** By Bill Thompson III. 2010. Houghton Mifflin Harcourt Publishing Company. 222 Berkeley Street, Boston, Massachusetts. 246 pages. 14.95 USD, Paper

* **Molt in North American Birds.** By S. Howell. 2010. Houghton Mifflin Harcourt Publishing Company. 222 Berkeley Street, Boston, Massachusetts 267 pages. 35 USD, Paper.

* **Birds of Ontario – Habitat Requirements, Limiting Factors, and Status. Volume 1 Non-passerines: Waterfowl through Cranes**. By Al Sandilands. 2010. UBC Press, University of British Columbia, 2029 West Mall, Vancouver, British Columbia V6T 1Z2. 392 pages. 95.00 CAD Cloth, 9.95 CAD Paper.

* **Birds of Ontario – Habitat Requirements, Limiting Factors, and Status. Non-passerines: Shorebirds Through Woodpeckers.** By Al Sandilands. 2010. UBC Press, University of British Columbia, 2029 West Mall, Vancouver, British Columbia V6T 1Z2. 392 pages. 95.00 CAD Cloth.

Butterflies of British Columbia. By C. Guppy and J. Shepard. 2010. Royal British Columbia Museum, 675 Belleville Street, Victoria, British Columbia V8W 9W2. UBC Press, 2029 West Mall, Vancouver British Columbia V6T 1Z2. 416 pages. 95.00 CAD.

Carnivores of British Columbia. By D. Hatler, D. Nagorsen, and A. Beal. 2010. Royal British Columbia Museum, 675 Belleville Street, Victoria, British Columbia V8W 9W2. 416 pages. 27.95 CAD.

Introducing the Dragonflies of British Columbia and the Yukon. By R. Cannings. 2010. Royal British Columbia Museum, 675 Belleville Street, Victoria, British Columbia V8W 9W2. 96 pages. 14.95 CAD.

Sea Cucumbers of British Columbia, Southeast Alaska and Puget Sound. By P. Lambert. 2010. Royal British Columbia Museum, 675 Belleville Street, Victoria, British Columbia V8W 9W2. UBC Press, 2029 West Mall, Vancouver, British Columbia V6T 1Z2. 176 pages. 24.95 CAD.

Possums, Shrews and Moles of British Columbia. By D. Nagorsen. 2010. Royal British Columbia Museum, 675 Belleville Street, Victoria, British Columbia V8W 9W2. UBC Press, 2029 West Mall, Vancouver, British Columbia V6T 1Z2. 176 pages. 24.85 CAD.

Rodents & Lagomorphs of British Columbia. By D. Nagorsen. 2010. Royal British Columbia Museum, 675 Belleville Street, Victoria, British Columbia V8W 9W2. 416 pages. 27.95 CAD.

Land Snails of British Columbia. By R. Forsythe. 2010. Royal British Columbia Museum, 675 Belleville Street, Victoria, British Columbia V8W 9W2. 192 pages. 25.95 CAD.

Brittle Stars, Sea Urchins and Feather Stars of British Columbia, Southeast Alaska and Puget Sound. By P. Lambert and W. Austin. 2010. Royal British Columbia Museum, 675 Belleville Street, Victoria, British Columbia V8W 9W2. 160 pages. 24.95 CAD

Sea Stars of British Columbia, Southeast Alaska and Puget Sound. By P. Lambert. 2010. Royal British Columbia Museum, 675 Belleville Street, Victoria, British Columbia V8W 9W2. UBC Press, 2029 West Mall, Vancouver, British Columbia V6T 1Z2. 102 pages. 25.95 CAD.

BOTANY

Catkin-bearing Plants of British Columbia. By T. C. Brayshaw. 2010. Royal British Columbia Museum, 675 Belleville Street, Victoria, British Columbia V8W 9W2. 220 pages. 24.95 CAD.

Systematics of Lasiopogon. By R. Cannings. 2010. Royal British Columbia Museum, 675 Belleville Street, Victoria, British Columbia V8W 9W2. 360 pages. 65 CAD.

Pondweeds, Bur-reeds and their Relatives of British Columbia. By T. C. Brayshaw. 2010. Royal British Columbia Museum, 675 Belleville Street, Victoria, British Columbia V8W 9W2. 256 pages. 24.95 CAD.

Trees and Shrubs of British Columbia. By T. C. Brayshaw. 2010. Royal British Columbia Museum, 675 Belleville Street, Victoria, British Columbia V8W 9W2. 220 pages. 24.95 CAD.

MISCELLANEOUS

Global Warming. Historical Guides to Controversial Issues in America. By Brian C. Black and Gary J. Weisel. 2010. Greenwood, Santa Barbara, California. 188 pages. ISBN 978-0-313-34522-7.

Plant Collecting for the Amateur. By T. C. Brayshaw. 2010. Royal British Columbia Museum, 675 Belleville Street, Victoria, British Columbia V8W. 48 pages. 5.95 CAD.

Rachel Carson – A Biography. By A. Quaratiello. 2010. Prometheus Books, 59 John Glenn Drive, Amherst, New York 14228-2119. 163 pages. 18 USD Paper.

News and Comment

Brenda Carter 1943-2010

Canadian wildlife artist Brenda Carter, 67, of Merrickville, Ontario, died 18 February 2010. Brenda was born in Calgary, but was raised in the Ottawa valley and later as a teen in Washington when her father, who was in the air force, was posted there. Her initial art training was in Florida and was dominated from its start by her love of animals and nature. In 1963, a return to Ottawa resulted in employment at the National Museum of Canada painting the backgrounds for dioramas. Also in the 1960s she worked for the Canadian Wildlife Service tagging Polar Bears and developed a love of the arctic. Subsequently, she met explorer-naturalist Tom Manning and was his companion on arctic expeditions and at his farm near Merrickville. After Tom died in 1968 she wrote a moving tribute to his life and accomplishments (Carter 2004). She painted not only northern animals in Canada but also those encountered on trips to Africa, Australia, Britain, the Galapagos Islands, and Central and South America. In the 1980s and 1990s she maintained her own gallery in Merrickville, and was a founder of the Merrickville artists tour which continues to the present. In 1999 she joined Ottawa bird enthusiast, and honourary member of the Ottawa Field-Naturalist's Club, Bruce Di Labio for *Feather Quest '90,* a challenge they set themselves to find and sketch at least 500 species of birds in travels across North America. They met this target in November and added an additional 14 species before the year ended. In 2005 she married biologist-artist Gerard Phillips, who she had met three years before while sketching at a bird migration in New York state. After an operation for a brain tumour in 2007 left her partially paralyzed, she trained herself to use her left hand and resumed painting, continuing to be productive until about four months before her death (Mazey 2010).

Literature Cited

Carter, Brenda. 2004. A tribute to Thomas Henry Manning, 1911-1998. *The Canadian Field-Naturalist* 118(4): 618-625.

Mazey, Steven. 2010. Obituary: Brenda Carter – Artist a keen observer of nature. *The Ottawa Citizen* 26 February 2010, page E5.

Canadian Association of Herpetologists Bulletin Association Canadienne des Herpetologistes 17(2), Spring 2010

Contents: Instructions for authors — EDITORIAL NOTES — MEETINGS: JMIH, CARCNet, CAH — FIELD NOTE: Herping on the Other Side of Planet Earth *by Richard Wassersug* — BOOK REVIEWS: *Turtles: The Animal Answer Guide (Gibbons and Greene) by Scott Gillingwater; Amphibian Ecology and Conservation: A Handbook of Techniques (Dodd) by Cindy Paszkowski* — THESIS ABSTRACTS IN CANADIAN HERPETOLOGY: **C. L. Browne.** Ph.D. 2010. University of Alberta, Edmonton, Alberta (Supervisor: Cindy Paszkowski) Habitat use of the Western Toad in North-central Alberta and the influence of scale — **Isabelle Ceillier.** B.Sc. 2010. University of Ottawa, Ottawa, Ontario (Supervisor: Gabriel Blouin-Demers) Does a temperature reversal trigger emergence in black ratsnakes? — **Jeff Graham.** B.Sc. 2010. University of Ottawa, Ottawa, Ontario (Supervisor: Gabriel Blouin-Demers) Assessing the thermoregulatory behaviour of a population of Blanding's Turtles (*Emydoidea blandingii*) on Grenadier Island — **Joël Leduc and Kristen Kozlowicz.** B.Sc. 2010. Laurentian University, Sudbury, Ontario (Supervisors: David Lesbarrères and Jacqueline Litzgus) Ecology of herpetofaunal populations in tailings wetlands in Sudbury, Ontario — **William McFadden**. B.Sc. 2010. Brandon University, Brandon, Manitoba (Supervisor: Pamela Rutherford) The Assiniboine River separates two genetically distinct clusters of the northern prairie skink (*Plestiodon septentrionalis*) — **Casey Peet-Paré.** B.Sc. 2010. University of Ottawa, Ottawa, Ontario. (Supervisor: Gabriel Blouin-Demers) Nest-site selection in Eastern Hognose Snakes (*Heterodon platirhinos*) — **Sophia Reilly.** B.Sc. 2010. University of Ottawa, Ottawa, Ontario. (Supervisor: Gabriel Blouin-Demers) The effect of chronic stress on the Painted Turtle (*Chrysemys picta*) in response to an environmental disturbance — **Jean-Sébastien Roy.** M.Sc. 2009. McGill University, Montréal, Quebec (Supervisor: David Green) Structure and dynamics of a natural hybrid zone between the toads, *Anaxyrus americanus* and *Anaxyrus hemiophrys*, in Southeastern Manitoba — RECENT PUBLICATIONS IN CANADIAN HERPETOLOGY— NEWS AND ANNOUNCEMENTS: The New Ontario Reptile and Amphibian Atlas — Membership Form.

Marine Turtle Newsletter 127, April 2010

SPECIAL ISSUE: MARINE TURTLES IN THE CARIBBEAN — Guest Editors: Robert Van Dam and Julia Horrocks — Articles: Guest Editorial: Marine Turtles of the Wider Caribbean Region (*Karen L. Eckert*) — Twelve years of monitoring hawksbill turtle (*Eretmochelys imbricata*) nesting at Doce Leguas Keys and Labyrinth, Jardines de la Reina Archipelago, Cuba (*Felix G. Moncada, Gonzalo Nodarse, Yosvani Medina and Erich Escobar*) — Leatherback Nest Distribution and Beach Erosion Pattern at Levera Beach, Grenada, West Indies (*Kimberly A. Maison, Rebecca King, Carl Lloyd and Scott Eckert*) — The Influence of Lunar, Tidal and Nocturnal Phases on the Nesting Activity of Leatherbacks (*Dermochelys coriacea*) in Tobago, West Indies (*A. Law, T. Clovis, G. R. Lalsingh and J. R. Downie*) — In-water Observations of Hawksbill (*Eretmochelys imbricata*) and Green (*Chelonia mydas*) Turtles in St. Kitts, Lesser Antilles (*R. Stimmelmayr, V. Latchman, and M. Sullivan*) — Monitoring Antigua's Hawksbills (*Eretmochelys imbricata*): A Population Update from More than Two Decades of Saturation Tagging at Jumby Bay (*Seth Stapleton, Dominic Tilley, and Kathryn Levasseur*) — Caribbean Leatherbacks: Results of Nesting Seasons from 1984-2008 at Culebra Island, Puerto Rico — *Carlos E. Diez, Rolando Soler, Giliberto Olivera, Abby White, Teresa Tallevast, Nancy Young & Robert P. van*

Dam) — Loggerhead Turtles in the Turks and Caicos Islands, Caribbean — *Thomas B. Stringell, Marta C. Calloso, John A. B. Claydon, Wesley Clerveaux, Brendan J. Godley, Quentin Phillips, Peter B. Richardson, Amdeep Sanghera and Annette C. Broderick)* — Hawksbill Tagged as a Juvenile in Puerto Rico Found Nesting in Panama 15 Years Later (*Cristina OrdoÃ'ez Espinosa, Anne B. Meylan, Peter A. Meylan, Isabel Peterson, Carlos E. Diez and Robert P. van Dam)* — Suzie the Green Turtle: 6,000 Kilometres for One Clutch of Eggs? — *Peter B. Richardson, Marta C. Calloso, John Claydon, Wesley Clerveaux, Brendan J. Godley, Quentin Phillips, Susan Ranger, Amdeep Sanghera, Thomas B. Stringell and Annette C. Broderick)* — MEETING REPORT: Third International Centro de Investigaciones Marinas Workshop on Sea Turtle Conservation in Cuba. Siguanea Bay, Isla de la Juventud, Cuba, April 22-30, 2009 (*Fernando Bretos and Julia Azanza Ricardo)* — IUCN SSC Marine Turtle Specialist Group Quarterly Update (*Nicolas J. Pilcher, Brian J. Hutchinson and Roderic B. Mast)* — BOOK REVIEWS — RECENT PUBLICATIONS.

The Marine Turtle Newsletter is edited by Lisa M. Campbell, Nicholas School of Environment and Earth Sciences, Duke University, 135 Duke Marine Lab Road, Beaufort, North Carolina 28516 USA; Subscriptions and donations to the production of the MTN can be made online at http://www.seaturtle.org/mtn/ or postal mail to Michael S. Coyne (Managing Editor), Marine Turtle Newsletter, A321 LSRC, Box 90328, Nicholas School of Environment and Earth Sciences, Duke University, Durham, North Carolina 27708-0328 USA; e-mail: mcoyne@seaturtle.org.

Editor's Report for Volume 123 (2009)

Mailing dates for issues in volume 123:
(1) 26 May 2010
(2) 5 November 2010
(3) 11 February 2011
(4) 11 April 2011

A summary of membership and subscriber distribution totals for 2009 is given in Table 1. The number of articles and notes in Volume 123 is summarized in Table 2 by topic; totals for Book Reviews and New Titles are given in Table 3, and the distribution of content by page totals per issue in Table 4.

The journal was printed at Gilmore Printers, Ottawa, and thanks are due business representative Tom Smith and customer representative Chuck Graham for overseeing production. Wendy Cotie prepared page layout and typesetting. Elizabeth Morton edited and proofed the galleys. Sandra Garland, the webmaster for the Ottawa Field-Naturalists' Club, posted tables of contents on the OFNC website. Leslie Cody prepared the Index for Volume 122. Duties of the Business Manager were carried out by Frank Pope, assisted by Assistant Treasurer Jim Ward. Roy John requested books for review and selected reviewers, edited submitted reviews, and prepared the new titles listings.

Manuscripts (excluding book reviews, notices, and reports) submitted to *The Canadian Field-Naturalist* totalled 67 in 2009. The following reviewed papers submitted in 2009 (with number of manuscripts reviewed in parentheses if more than one):

Associate Editors:

R. Anderson, Canadian Museum of Nature, Ottawa, Ontario (4); W. B. Ballard, Texas Tech University, Lubbock, Texas (19); C. D. Bird, Erskine, Alberta (5); R. R. Campbell, St. Albert, Ontario (3); P. M. Catling, Agriculture and Agri-Food Canada, Ottawa, Ontario (5); B. W. Coad, Canadian Museum of Nature, Ottawa, Ontario (4); A. J. Erskine, Sackville, New Brunswick (14); D. F. McAlpine, New Brunswick Museum, Saint John, New Brunswick (4); D. W. Nagorsen, Mammalia Biological Consulting, Victoria, British Columbia (4); W. O. Pruitt, Jr., University of Manitoba, Winnipeg, Manitoba (6).

Others: E. Bayne, University of Alberta, Edmonton, Alberta; L. Bernal, Texas Tech University, Lubbock, Texas; J. S. Bleakney, Wolfville, Nova Scotia; J. Bogart, University of Guelph, Ontario; S. Breck, National Wildlife Research Center-APHIS, Fort Collins, Colorado; I. Brodo, Canadian Museum of Nature, Ottawa, Ontario; R. Brooks, University of Guelph, Guelph, Ontario (3); D. Brunton, Ottawa, Ontario; J. Cain, Texam, Commerce, Texas; L. Carbyn, Canadian Wildlife Service and University of Alberta, Edmonton (2);

TABLE 1. The 2009 circulation of The Canadian Field-Naturalist (2008 in parenthesis). Compiled by Frank Pope from the mailing list for 123(4).

	Canada		USA		Other		Total	
Memberships								
Family & individual	517	(552)	21	(24)	2	(2)	540	(578)
Subscriptions								
Individual	95	(101)	34	(37)	3	(3)	132	(141)
Institutional	142	(129)	196	(185)	28	(30)	366	(344)
Total	754	(782)	251	(246)	33	(35)	1038	(1063)

TABLE 2. Number of articles and notes published in *The Canadian Field-Naturalist*, Volume 122 (2008), by major field of study.

Subject	Articles	Notes	Total
Mammals	15	16	31
Birds	6	4	10
Amphibians and reptiles	4	0	4
Fish	6	0	6
Plants	4	2	6
Other	1	0	1
Total	36	22	58

TABLE 3. Number of reviews and new titles published in the Book Review section of *The Canadian Field-Naturalist*, Volume 122, by topic.

	Reviews	New Titles
Zoology	34	55
Botany	8	7
Environment	10	5
Miscellaneous	14	24
Total	58	91

TABLE 4. Number of pages per section published in *The Canadian Field-Naturalist*, Volume 122 (2008), by issue.

	Issue				
	1	2	3	4	Total
Articles	67	66	61	69	263
Notes	4	17	8	9	38
Book Reviews*	24	13	18	15	70
CFN/OFNC Reports **	0	2	8	4	14
News and Comment	2	1	5***	3	7
Index			20	20	
Advice to Contributors	1	1	0	0	2
Total	98	100	100	120	418

* Total pages for book review section include both reviews and new titles listings.
** Includes CFN Editor's report in number 2, Minutes of the OFNC Annual Business Meeting in number 3, and OFNC Awards in number 4.
*** Includes a 4-page opinion article.

K. Chaulk, Labrador Institute, Memorial University of Newfoundland Goose Bay, Labrador, Newfoundland and Labrador; T. Chubbs, Department of National Defense, Goose Bay, Newfoundland and Labrador; D. Cluff, Environment and Natural Resources of the Northwest Territories, Yellowknife, Northwest Territories (2); S. Cooke, Carleton University, Ottawa, Ontario; V. Crichton, Manitoba Natural Resources, Winnipeg, Manitoba; S. Cumbaa, Canadian Museum of Nature, Ottawa; C. M. Davy, University of Toronto, Ontario; C. Edge, University of New Brunswick, Fredericton; R. Erickson, Texas Tech University, Lubbock, Texas (2); D. A. Galbraith, Royal Botanical Gardens, Hamilton and Burlington, Ontario; J. Gilhen, Nova Scotia Museum of Natural History, Halifax, Nova Scotia (4); A. Giordano, Texas Tech University, Lubbock, Texas; M. Gosselin, Canadian Museum of Nature, Ottawa, Ontario; P. Gregory, University of Victoria, British Columbia; F. H. Harrington, Mount Saint Vincent University, Halifax, Nova Scotia; A. Hebda, Nova Scotia Museum of Natural History, Halifax, Nova Scotia; C. S. Houston, Saskatoon, Saskatchewan (4); H. Howden, Ottawa, Ontario; R. James, Sunderland, Ontario; J. Kamler, Lenexa, Kansas (2); J. Lefebvre, Service canadien de la faune, Québec, Québec; J. D. Litzgus, Laurentian University, Sudbury, Ontario; R. MacCulloch, Royal Ontario Museum, Toronto, Ontario (2); M. K. McNicholl, Burnaby, British Columbia; J. McRoberts, Texas Tech University, Lubbock, Texas; D. Mech, U.S. Geological Survey, and The Raptor Center, University of Minnesota, St. Paul, Minnesota (7); B. Morris, Department of Natural Resources, Fairbanks, Alaska; D. Naughton, Canadian Museum of Nature, Ottawa, Ontario; M. E. Obbard, Ontario Ministry of Natural Resources, Peterborough, Ontario; M. Panasci, Texas Tech University, Lubbock, Texas; R. Pittaway, Minden, Ontario; G. Proulx, Alpha Research & Management Ltd., Sherwood Park, Alberta (2); J. Rising, University of Toronto, Ontario; K. Ruckstuhl, University of Calgary, Alberta; R. A. Saumure, Las Vegas, Nevada; J. Schieck, Alberta Biodiversity Monitoring Institute, Vegreville, Alberta; F. W. Schueler, Bishops Mills Natural History Center, Bishops Mills, Ontario (5); D. Seburn, Ottawa, Ontario; N. Tatman, Texas Tech University, Lubbock, Texas; and one additional reviewer who specifically requested not be identified in any manner.

I am, as ever, indebted the President and Council of the Ottawa Field-Naturalists' Club and to Chairman Ron Bedford and the Publications Committee of the OFNC for continuing support, to the Canadian Museum of Nature for access to its library and the facilities at the Natural Heritage Building, 1740 Pink Road, Gatineau (Aylmer), Quebec, and to Joyce for continuing support.

FRANCIS R. COOK
Editor

Mailing date of the previous issue 124(1): 19 April 2011

Articles

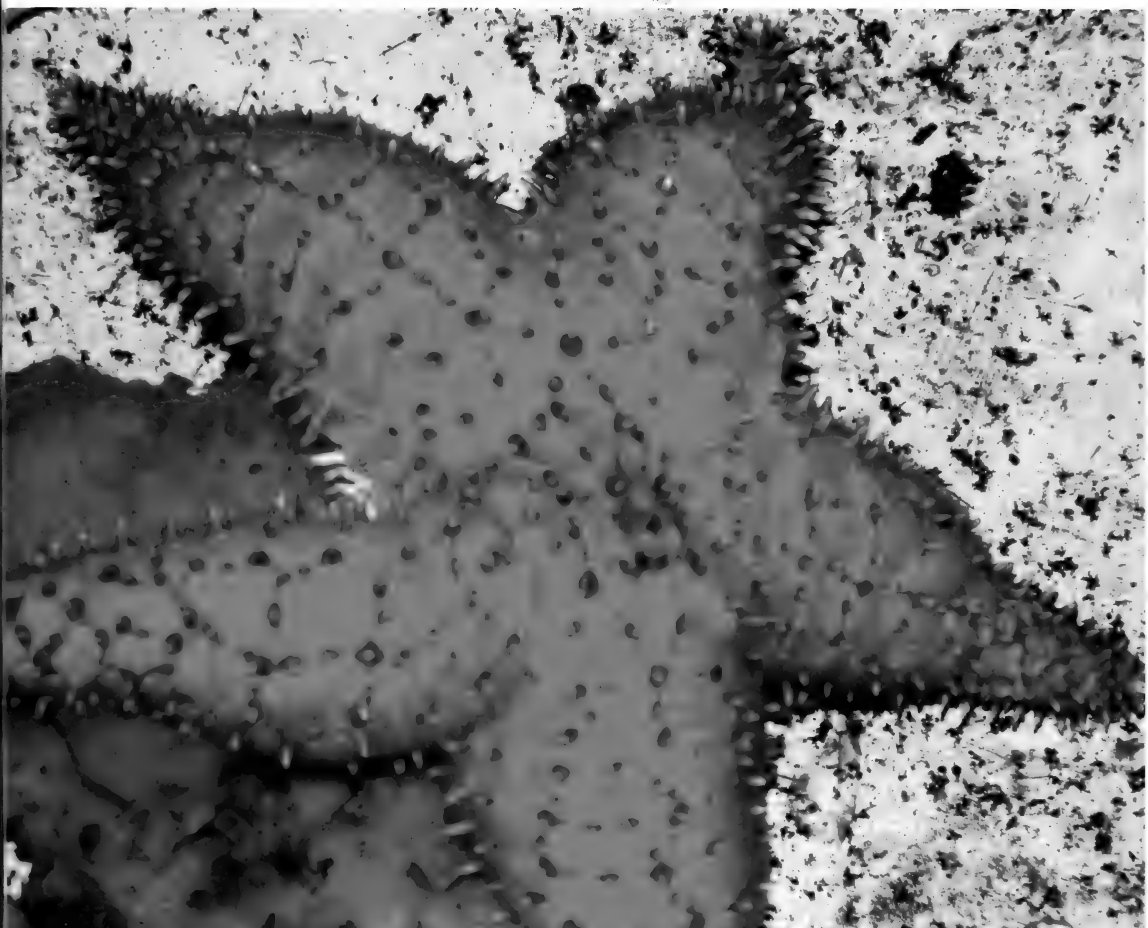
Notes

(continued on inside back co

ISSN 0008-3550

The CANADIAN FIELD-NATURALIST

Published by THE OTTAWA FIELD-NATURALISTS' CLUB, Ottawa, Canada



Volume 124, Number 3 July–September 2010 0

The Canadian Field-Naturalist

The *Canadian Field-Naturalist* is published quarterly by The Ottawa Field-Naturalists' Club. Opinions and ideas expressed in this journal do not necessarily reflect those of The Ottawa Field-Naturalists' Club or any other agency.

Editor: Dr. Francis R. Cook, R.R. 3, North Augusta, Ontario K0G 1R0; (613) 269-3211; e-mail: cfn@ofnc.ca
Copy Editor: Elizabeth Morton
Business Manager: Frank Pope, P.O. Box 35069, Westgate P.O. Ottawa, Canada K1Z 1A2
Book-review Editor: Roy John, 2193 Emard Crescent, Ottawa, Ontario K1J 6K5; e-mail: r.john@rogers.ca

Associate Editors: Robert R. Anderson, Warren B. Ballard, Charles D. Bird, Robert R. Campbell, Paul M. Catling, Brian W. Coad, Anthony J. Erskine, David Nagorsen, Donald F. McAlpine

Chairman, Publications Committee: Ronald E. Bedford

All manuscripts intended for publication except Book Reviews should be addressed to the Editor and sent by e-mail (attached) or postal mail (with disk).

Book-review correspondence should be sent by e-mail or postal mail to Roy John, Book-review Editor.

Subscriptions and Membership
Subscription rates for individuals are $33 per calendar year. Libraries and other institutions may subscribe at the rate of $50 per year (volume). The Ottawa Field-Naturalists' Club annual membership fee of $33 (individual) $35 (family) $50 (sustaining) and $500 (life) includes a subscription to *The Canadian Field-Naturalist*. All foreign subscribers and members (including USA) must add an additional $5.00 to cover postage. The club regional journal, *Trail & Landscape*, covers the Ottawa District and Local Club events. It is mailed to Ottawa area members, and available to those outside Ottawa on request. It is available to Libraries at $33 per year. Subscriptions, applications for membership, notices of changes of address, and undeliverable copies should be mailed to: The Ottawa Field-Naturalists Club, P.O. Box 35069, Westgate P.O. Ottawa, Canada K1Z 1A2. Canada Post Publications Mail Agreement number 40012317. Return Postage Guaranteed. Date of this issue: July – September 2010 (June 2011).

COVER: The strikingly beautiful and rare Thorny Sea Star, *Poraniopsis inflatus*, has embedded spines it exposes to other sea stars when threatened by them. Photo by Shawn Larson, the Seattle Aquarium. See pages 199-203.

The Canadian Field-Naturalist

Volume 124, Number 3 July–September 2010

Arm Deflation in the Rare Thorny Sea Star, *Poraniopsis inflatus* (Asteroidea: Poraniidae), A Defensive Response to other Sea Stars?

ROLAND C. ANDERSON[1] and RONALD L. SHIMEK[2]

[1] 2000 Minor E., #8, Seattle, Washington 98102 USA
[2] PO Box 4, Wilsall, Montana 59086 USA

Anderson, Roland C., and Ronald L. Shimek. 2010. Arm deflation in the rare Thorny Sea Star, *Poraniopsis inflatus* (Asteroidea: Poraniidae), a defensive response to other sea stars? Canadian Field-Naturalist 124(3): 199–203.

The Thorny Sea Star, *Poraniopsis inflatus,* is rare in the Northeastern Pacific. It lacks pedicellariae or other overt defenses for protection against other predatory sea stars. During an earlier study, a *P. inflatus* confronted by an asteroid-eating sea star was observed to exhibit a possible defensive reaction: "arm deflation." It was 15 years before another *P. inflatus* specimen could be obtained and that hypothesis confirmed by testing with individuals of 18 other sea-star species. Contact with individuals of four predatory sea-stars, *Asterina miniata*, *Crossaster papposus*, *Solaster dawsoni*, and *Pycnopodia helianthoides*, elicited the reaction in the *P. inflatus*. The specimen collapsed ("deflated") an arm closest to the predatory star, possibly by expelling coelomic fluid, exposing more of its embedded thorns (hence its common name) which may discourage other sea stars from attempting to eat it.

Key Words: Thorny Sea Star, *Poraniopsis inflatus*, escape response, defensive reaction, predator-prey interaction.

The diverse sea star fauna of the Northeastern Pacific has been relatively well-described (D'yakonov 1968; Lambert 1981, 2000; Austin 1985; Kozloff 1987). As early as 1911, Fisher stated that there were "more sea stars of more species" found in the Oregonian biome between Alaska and California there than anywhere else in the world. Given that over 100 species have been reported from that region (Austin 1985), it is obvious that statement has substantial credence. While numerous field observations in this region along with laboratory and field experiments have demonstrated the ecological importance of a few relatively common asteroid species in many shallow-water communities (Paine 1966, 1974; Mauzey et al. 1968; Engstrom 1974; Quinn 1982; Duggins 1983), the natural history and ecological relationships of most sea-star species in the region remain largely unknown. This is particularly true of the rarer, generally deeper-water, species where even a few experimental natural history observations, such as those by Anderson and Shimek (1993) on *Poraniopsis inflatus* (Fisher 1910), may contribute important information to the overall knowledge of this group.

Predatory, highly mobile and, often, ecologically dominant predators, sea stars are well known for eliciting escape responses in many other animals including other asteroids. Documented escape responses in sea stars include rapid directed locomotion escapes, ray autonomy, arms raised in defensive postures, and presenting their suckered tube feet to the predator (Mauzey et al. 1968). Some sea stars possess an arsenal of formidable pedicellariae on their aboral surfaces. These structures, spines modified as small biting jaws, have been hypothesized to keep the star's aboral surface clean (Hyman 1955), but are known to be used by some species to capture prey (Robilliard 1971; Chia and Amerongen 1977), and also to repel predators (Mauzey et al. 1968). Sea stars lacking these effective defensive structures or defensive behaviors run the risk of being eaten by other asteroids, such as *Solaster dawsoni*, which are known to consume other sea stars (Mauzey et al. 1968).

A member of the Asteroid taxonomic Family Poraniidae, *Poraniopsis inflatus* (Fisher, 1910) lacks pedicellariae. Initially described as *Alexandraster inflatus*, Fischer 1906, revised to *Poraniopsis inflata* by Fisher in 1910, and finally revised to *P. inflatus* by Clark in 1993 (Lambert 2000), this species ranges from Alaska to southern California, but is rare throughout that region. In the century since its description, only 12 specimens have been documented from British Columbia and Washington (Lambert 1981, 2000; Anderson and Shimek 1993). It is found in high-energy shallow environments (Anderson and Shimek 1993) and on the shallow continental shelf (Alton 1966); whether it is found in between these two disparate habitats is unknown. Little is known of the natural history, including any possible defensive or escape responses,

Sex Ratio, Body Mass, and Harvest Rates for Five Sympatric Mammalian Carnivores in the Canadian Prairies

SERGE LARIVIÈRE[1,2,3], VANCE LESTER[2], and WANDA GORSUCH[1]

[1]Delta Waterfowl Foundation, R.R. # 1 Box 1, Site 1, Portage La Prairie, Manitoba, R1N 3A1 Canada
[2]Department of Biology, University of Saskatchewan, 112 Science Place, Saskatoon, Saskatchewan S7N 5E2 Canada
[3]Present address: Cree Hunters and Trappers Income Security Board, 2700 Laurier, Champlain #1100, Quebec, Quebec G1V 4K5 Canada; e-mail: slariviere@osrcpc.ca

Larivière, Serge, Vance Lester, and Wanda Gorsuch. 2010. Sex ratio, body mass, and harvest rates for five sympatric mammalian carnivores in the Canadian prairies. Canadian Field-Naturalist 124(3): 204–208.

We assessed sex ratio, body mass, and harvest rates for 5 species of carnivores (Mammalia: Carnivora) collected in southern Saskatchewan, Canada during spring and summer 1999-2001. Overall, 647 adult carnivores were collected; captures consisted mostly of Striped Skunk (*Mephitis mephitis,* 50.7% of captures, 2.6±0.6 kg), Raccoon *(Procyon lotor;* 28.3%, 6.5±1.3 kg), American Badger (*Taxidea taxus*, 8.2%, 7.7±1.5 kg), Red Fox (*Vulpes vulpes,* 7.7%, 4.6±0.6 kg), and Coyote (*Canis latrans*, 5.1%,11.0±1.5 kg). Sex ratio (M:F) of captures was male-biased for Raccoon (2.5:1), Striped Skunk (1.7:1), but did not differ from 1:1 for American Badger (2.3:1), Coyote (1.7:1), or Red Fox (2.2:1). For both Striped Skunk and Raccoon, the temporal variation in sex ratio of captures suggests that males were more vulnerable to capture early in the spring than females. Harvest rates were highest for Striped Skunks (range 0.8-2.2 animals/km^2) followed by Raccoons (0.4-1.3 animals/km^2), American Badgers (0.2-0.5 animal/km^2), Red Foxes (0.2-0.4 animal/km^2), and Coyotes (0.1-0.4 animals/km^2).

Key Words: American Badger, *Taxidea taxus*, Coyote, *Canis latrans*, Raccoon, *Procyon lotor,* Red Fox, *Vulpes vulpes,* Striped Skunk, *Mephitis mephitis,* Saskatchewan.

Programs that aim to reduce predator populations are often performed to help increase production of game animals (e.g., Garretson and Rohwer 2001). The collection of animal carcasses during these projects allows biologists to gain valuable basic information on predator morphometrics and abundance. For example, variables such as body mass and sex ratio are often hard to collect during livetrapping studies because of limited sample sizes, and the largest samples are typically obtained as a by-product of culling operations (e.g., Cavallini 1997). Similarly, removal operations may provide insights into animal abundance, with possible biases due to immigration or vulnerability to capture. Nonetheless, density estimates of many carnivorous species are unavailable for many areas where more conventional and more rigorous methods such as capture-mark-recapture or radio-telemetry have not been performed (Smallwood and Schonewald 1998).

The Prairie Pothole Region of North America extends from Alberta, Saskatchewan, and Manitoba in Canada south to Montana, North Dakota, South Dakota, Minnesota and parts of Iowa in the United States. This region constitutes the major breeding area for many species of ground-nesting ducks (Anatidae), and the reproductive success of these ground nesting ducks and many other grassland birds is limited by predation of their eggs (Böhning-Gaese et al. 1993; Hoekman et al. 2002). In most of the Prairie Pothole Region, mammalian carnivores such as Striped Skunks (*Mephitis mephitis*), Red Foxes (*Vulpes vulpes*), Raccoons (*Procyon lotor*), American Badgers (*Taxidea taxus*), and Coyotes (*Canis latrans*) are the most important predators of duck eggs (Johnson et al. 1989). Herein, we took advantage of predator control operations performed to increase nest success of upland nesting ducks to obtain information on sex ratio, body mass and harvest rates of five sympatric species of prairie carnivores (Striped Skunk, Raccoon, Red Fox, American Badger and Coyote).

Study Area

Work was conducted ca. 75 km southwest of Weyburn, in the vicinity of the towns of Ceylon and Ogema in the province of Saskatchewan, Canada: Primary land use is cultivation of cereal and oil seed crops, as well as livestock production. Much of the area is cultivated annually although some small (typically <1.3 km^2) parcels of native grassland pasture and hay production areas are present. The area is typified by rolling hills with a high density of semi-permanent, seasonal and ephemeral wetlands. The study area lies within the grassland ecoregion of Saskatchewan where native vegetation communities are typically grassland or grassland-short shrub communities. Common native plant species in the area include several grasses (*Agropyron* sp., *Boutleloua* sp., *Festuca* sp., *Hordeum* sp., *Koeleria* sp., *Poa* sp., *Stipa* sp.), shrubs such as Western Snowberry (*Symphoricarpos occidentalis*), Rose (*Rosa* sp.), Silverberry (*Elaeagnus communtata*), and various forbs. Naturally occurring tree communities

are rare, and most trees occur as planted shelter belts to shield farmstead and agricultural land from prevailing winds.

Methods

Each year (1999-2001), target animals were harvested in two experimental areas of 6.4 km × 6.4 km (41 km^2) for a total of six study areas (respectively named Ceylon, Edgeworth, Hardy, Kayville, Pangman, and Radville), each trapped for only one year. Composition of all areas varied slightly, but all included contiguous areas composed of < 20% native grassland or planted hayland. Study areas in each year of the study were separated by at least 6.4 km to reduce possibility of overlapping treatment effects among years.

On each study area, animals were harvested by professional trappers from 20 April to 1 July 1999, and from 10 March to 15 July 2000 and 2001. The intent was to remove all animals present on the study blocks, so trapping effort was extremely intensive (8 700 – 11 000 trap-nights per site), and standard capture methods (bodygripping traps, foothold traps, and cage-type livetraps) were supplemented by opportunistic shooting, calling, and denning. Trappers recorded date of capture, species, age (juvenile or adult), sex and body mass for animals captured. In 1999, animals were not weighed so only gender, species and date of capture were recorded. Most animals were harvested before the emergence of young from natal dens, and only adults were included in analyses. All procedures were approved by the University of Saskatchewan Animal Care Committee (UCACS protocol #20010055).

Results

A total of 647 adult carnivores were collected during 1999-2001. Of all animals captured, Striped Skunks and Raccoons represented the largest samples, with 50.7% and 28.3% of the captures, respectively. Other species consisted of American Badger (8.2%), Red Fox (7.7%), and Coyote (5.1%).

Sex ratio (M:F) of captures was male-biased for Raccoon (2.5:1, n = 183; Fisher exact test, P <0.001), Striped Skunk (1.7:1, n = 321; P = 0.003), but did not differ from 1:1 for American Badger (2.3:1, n = 50; P = 0.066), Red Fox (2.2:1, n = 39; P = 0.107) and Coyote (1.7:1, n = 33; P = 0.464). We examined variations in sex ratio over time for the two most commonly captured species, Striped Skunk (n = 321) and Raccoon (n = 180; date was not recorded for three animals). Sex ratio of captures varied throughout the summer for both species (Figure 1). For Striped Skunks, males dominated the captures during early spring, and the sex ratio balanced by 16-30 April, then returned to mostly males for the rest of the summer (Figure 1A). For Raccoons, no females were captured before 16 March, and males dominated the captures for all periods except 16-30 March (Figure 1B).

We obtained mass for 428 (82.4%) of 519 adult animals captured during 2000-2001 (Table 1). There was significant sexual dimorphism in mass, with males being larger, for Striped Skunk (Student t-test, t = -5.4, df = 201, P <0.001), Raccoon (t = -3.4, df = 119, P = 0.001), Red Fox (t = -3.2, df = 34, P = 0.003), American Badger (t = -5.8, df = 28, P < 0.001), and the difference approached significance for Coyote (t = -1.9, df = 27, P = 0.070). The largest dimorphism index (male mass/female mass) was observed for American Badger (1.37).

We estimated harvest rates based on the number of captures per unit area for each of 6 study areas (Table 2). Harvest rates were highest for Striped Skunks (average 1.3 animal/km^2), followed by Raccoons (0.7 animal/km^2), whereas <0.5 animals/km^2 were captured for Red Foxes, Badgers and Coyotes (Table 2).

Discussion

Our results provide valuable morphological and ecological information. First, sex ratio of captures was male-biased for both Striped Skunks and Raccoons. The chronology in harvest of Striped Skunks and Raccoons indicate clearly the harvest was biased towards male during the early season (up to June) when the sex ratio of captures becomes more even. The temporal distribution of captures by gender supports several biological arguments regarding movements of carnivores, especially for Skunks and Raccoons. First, males typically have larger home range than females and thus may be more vulnerable to capture (Gehrt and Fritzell 1996; Larivière and Messier 1998). Second, at least for Striped Skunks, males typically are the first animals to emerge from winter dens (Wade-Smith and Verts 1982). Thus, one would predict that early spring captures would be male-biased, whereas females would become more abundant in late spring captures. This is what our data indicate, for both Skunks and Raccoons.

In our study, Striped Skunks and Raccoons were the most often captured predators. Although these estimates of abundance may not truly represent density because of possible positive bias due to immigration (especially dispersal of male Striped Skunks in June — Sargeant et al. 1982), negative biases due to trap-shy animals (Gehrt and Fritzell 1996), or because of immigration of neighbours following removal of residents. Nonetheless, our harvest rates were very comparable to estimates of abundance provided for similar habitats. For example, our harvest rates for Striped Skunk (0.8-2.2 animals/km^2) are comparable to overall density estimates for the species (1.8-4.8/km^2 — Wade-Smith and Verts 1982), and certainly a good representation of densities observed in adjacent North Dakota (0.7-0.9/km^2 — Greenwood et al. 1985). Similarly, our estimates of abundance for American Badgers (0.2-0.5/km^2) and Coyotes (0.1-0.4/km^2) are also well within ranges reported in the literature (0.2-0.4 animals/km^2 for both American Badgers [Messick 1987]

TABLE 1. Spring body mass (kg) of adults of five sympatric prairie carnivores collected during in southern Saskatchewan, 1999-2001.

Species	Males			Females			Both sexes			Sexual dimorphism
	Mean	SE	*n*	Mean	SE	*n*	Mean	SE	*n*	(male mass/female mass)
Striped Skunk	2.8	0.6	136	2.4	0.4	75	2.6	0.6	211	1.17
Raccoon	6.8	1.1	94	5.9	1.4	28	6.5	1.3	122	1.15
Red Fox	4.8	0.5	23	4.3	0.5	13	4.6	0.6	36	1.11
American Badger	8.5	1.0	19	6.2	1.0	11	7.7	1.5	30	1.37
Coyote	11.3	1.3	17	10.3	1.2	12	11.0	1.5	29	1.09

TABLE 2. Harvest rates of mammalian carnivores for 6 study areas of 41 km^2 (16 miles^2) during predator control operations conducted in southern Saskatchewan, 1999-2001. Only Striped Skunks and Raccoons were targeted for removal during 1999.

		Species									
		Striped Skunk		*Raccoon*		*Red Fox*		*American Badger*		*Coyote*	
Study Area	Year	*n*	#/km^2	*n*	#/km^2	*n*	#/km^2	*n*	#/km^2	*n*	#/km^2
Ceylon	1999	69	1.7	18	0.4	–	–	–	–	–	–
Edgeworth	1999	34	0.8	21	0.5	–	–	–	–	–	–
Radville	2000	91	2.2	23	0.6	15	0.4	13	0.3	5	0.1
Pangman	2000	54	1.3	53	1.3	15	0.4	9	0.2	7	0.2
Kayville	2001	37	0.9	52	1.3	14	0.3	10	0.2	15	0.4
Hardy	2001	43	1.0	16	0.4	11	0.3	21	0.5	6	0.1
Average	1999–2001	55	1.3	31	0.7	13	0.4	13	0.3	8	0.2
Total	1999–2001	328	n/a	183	n/a	50	n/a	53	n/a	33	n/a

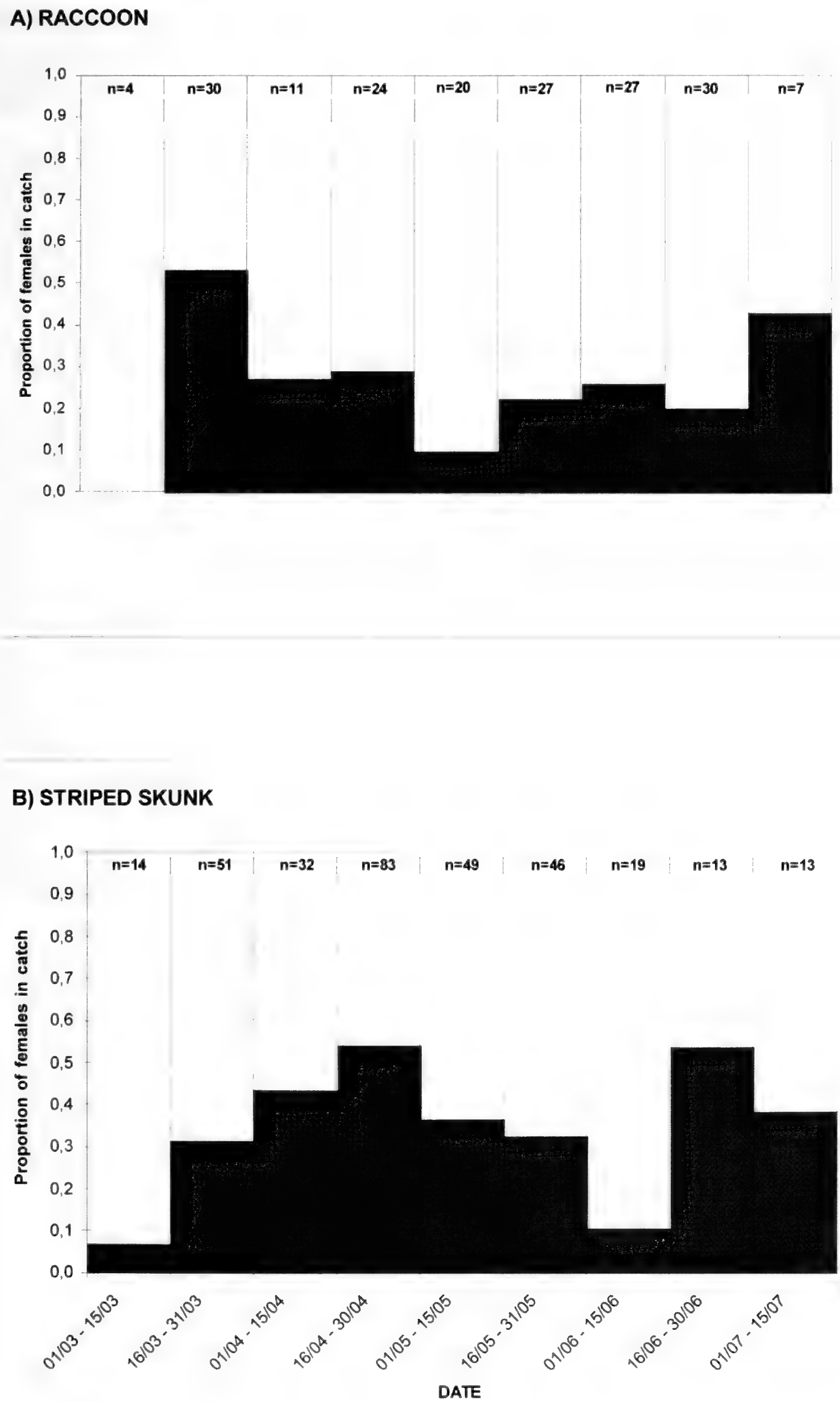


FIGURE. 1. Bi-weekly variation in sex ratio for A) Raccoons (n = 180), and B) Striped Skunks (n = 320) collected during predator control operations performed in southern Saskatchewan, 1999-2001.

and Coyotes [Voigt and Berg 1987]). However, our harvest rates for Red Fox (0.3-0.4/km^2) are comparable to abundance observed for Red Fox in Poland (0.4/km^2 — Goszczynski 1989), but overall lower than estimates of density for other parts of the world (typically between 1-2 animals/km^2 —Larivière and Pasistchniak-Arts 1996).

Our harvest rates for Raccoons for southern Saskatchewan are similar to density estimates in adjacent North Dakota (0.5-1.0/km^2 — Fritzell 1978). However, these estimates are much lower than almost anywhere else in the range of the species (range 1-100 animals/km^2 — Gehrt 2002). Raccoons are a relatively new inhabitant of the prairies, and were relatively uncommon in the Canadian prairies up to 1950 (Gehrt 2002). However, Raccoons have expanded their range considerably since the turn of the century, and are now omnipresent in the Canadian prairies (Larivière 2004).

Acknowledgments

This research was funded by the Delta Waterfowl Foundation, the Institute for Wetland and Waterfowl Research of Ducks Unlimited Inc., with logistic support from the Canadian Wildlife Service. D. Gordon, B. Poncelet, and D. Paslawski conducted the trapping. M. Borgreen, F. Dillemuth, M. Eiswerth, J. Gansen, A. Hoffman, M. Kaminski, C. Michie, R. Olson, N. Wiebe, and M. Wise assisted with the field work. J. A. Pitt, Y. T. Hwang, and E. C. Hellgren reviewed earlier drafts of this manuscript.

Literature Cited

Böhning-Gaese, K., M. L. Taper, and **J. H. Brown.** 1993. Are declines in North American insectivorous songbirds due to causes on the breeding range? Conservation Biology 7: 76-86.

Cavallini, P. 1997. Internal organ masses of the red fox *Vulpes vulpes*: data from the wild. Acta Theriologica 42: 91-98.

Fritzell, E. K. 1978. Aspects of raccoon (*Procyon lotor*) social organization. Canadian Journal of Zoology 56: 260-271.

Garretson, P. R., and **F. C. Rohwer.** 2001. Effects of mammalian predator removal on production of upland-nesting ducks in North Dakota. Journal of Wildlife Management 65: 398-405.

Gehrt, S. D. 2002. Raccoon. *In*: Wild Mammals of North America: Biology, Management, and Economics. *Edited by* G. A. Feldhamer, B. Thompson, and J. A. Chapman. Johns Hopkins University Press, Baltimore.

Gehrt, S. D., and **E. K. Fritzell.** 1996. Sex-biased responses of raccoons (*Procyon lotor*) to live traps. American Midland Naturalist 135: 23-32.

Goszczynski, J. 1989. Spatial distribution of red foxes *Vulpes vulpes* in winter. Acta Theriologica 34: 361-372.

Greenwood, R. J., A. B. Sargeant, and **D. H. Johnson.** 1985. Evaluation of mark-recapture for estimating striped skunk abundance. Journal of Wildlife Management 49: 332-340.

Greenwood, R. J., A. B. Sargeant, D. H. Johnson, L. M. Cowardin, and **T. L. Shaffer.** 1995. Factors associated with duck nest success in the Prairie Pothole Region of Canada. Wildlife Monographs 128: 1-57.

Greenwood, R. J., A. B. Sargeant, J. L. Piehl, D. A. Buhl, and **B. A. Hanson.** 1999. Foods and foraging of prairie striped skunks during the avian nesting season. Wildlife Society Bulletin 27: 823-832.

Hoekman, S. T., L. S. Mills, D. W. Howerter, J. H. Devries, and **I. J. Ball.** 2002. Sensitivity analyses of the life cycle of mid-continent mallards. Journal of Wildlife Management 66: 883-900.

Johnson, D. H., A. B. Sargeant, and **R. J. Greenwood.** 1989. Importance of individual species of predators on nesting success of ducks in the Canadian Prairie Pothole Region. Canadian Journal of Zoology 67: 291-297.

Larivière, S. 2004. Range expansion of raccoons in the Canadian prairies: review of hypotheses. Wildlife Society Bulletin 32: 955-963.

Larivière, S., and **F. Messier.** 1998. Spatial organization of a prairie striped skunk population during the waterfowl nesting season. Journal of Wildlife Management 62: 199-204.

Larivière, S., and **M. Pasitschniak-Arts.** 1996. *Vulpes vulpes*. Mammalian Species 537: 1-11.

Messick, J. P. 1987. North American badger. *In*: Wild Furbearer Management and Conservation in North America. *Edited by* M. Novak, J. A. Baker, M. E. Obbard, and B. Malloch. Toronto: Ontario Ministry of Natural Resources, Canada.

Sargeant, A. B., R. J. Greenwood, J. L. Piehl, and **W. B. Bicknell.** 1982. Recurrence, mortality, and dispersal of prairie Striped Skunks, *Mephitis mephitis*, and implications to rabies epizootiology. Canadian Field-Naturalist 96: 312-316.

Smallwood, K. S., and **C. Schonewald.** 1998. Study design and interpretation of mammalian carnivore density estimates. Oecologia 113: 474-491.

Voigt, D. R., and **W. E. Berg.** 1987. Coyote. Pages 345-357 *in* Wild Furbearer Management and Conservation in North America. *Edited by* M. Novak, J. A. Baker, M. E. Obbard, and B. Malloch. Toronto: Ontario Ministry of Natural Resources, Canada.

Wade-Smith, J., and **B. J. Verts.** 1982. *Mephitis mephitis*. Mammalian Species 173: 1-7.

Received 30 June 2009
Accepted 8 November 2010

Observations of Bobcats, *Lynx rufus*, Hunting Black-Tailed Prairie Dogs, *Cynomys ludovicianus*, in Western South Dakota

Daniel S. Licht

National Park Service, 231 E. St. Joseph Street, Rapid City South Dakota 57701 USA; e-mail: dan_licht@nps.gov

Licht, Daniel S. 2010. Observations of Bobcats, *Lynx rufus*, hunting Black-Tailed Prairie Dogs, *Cynomys ludovicianus*, in western South Dakota. Canadian Field-Naturalist 124(3): 209–214.

There is a paucity of scientific literature describing Bobcat (*Lynx rufus*) hunting strategies. I document 13 observations of Bobcats hunting Black-tailed Prairie Dogs (*Cynomys ludovicianus*) in western South Dakota. In all cases the Bobcats stationed themselves next to a prairie dog mound in an attempt to ambush prairie dogs emerging from their burrows. In eight cases the Bobcats successfully captured a prairie dog emerging from the burrow, in one case the Bobcat turned and captured a prairie dog that had walked up behind it, and in the other cases the Bobcats lunged at the burrow openings, but did not capture a prairie dog. There were two variations of the tactic: in some cases Bobcats entered a colony prior to prairie dog emergence and stationed themselves next to a mound, whereas in other cases Bobcats stationed themselves next to a burrow that a prairie dog had just escaped to. One Bobcat appeared to have waited next to the same mound for at least 7.5 hr. Prairie dogs may comprise a large portion of a Bobcat's winter diet in landscapes where prairie dog colonies exist in close proximity to badlands or woody cover.

Key Words: Black-tailed Prairie Dog, *Cynomys ludovicianus*, Bobcat, *Lynx rufus*, hunting, predation, tactic, South Dakota.

Information and detailed observations of Bobcat (*Lynx rufus*) hunting methods and predation events are rare in the scientific literature, likely due in part to its relatively low density and secretive nature. Anderson and Lovallo (2003) reviewed Bobcat ecology and suggested that Bobcats primarily hunt by stalking and springing, or by ambushing. Jacques and Jenks (2008) observed a Bobcat using a stalking and springing approach to kill a female Pronghorn Antelope (*Antilocapra americana*). Biggins and Biggins (2006) observed a Bobcat using a stalking and springing approach to kill a cottontail rabbit (*Sylvilagus* sp.). However, Johnsgard (2005) stated that a stalking and springing approach would be difficult to employ in capturing Black-tailed Prairie Dogs (*Cynomys ludovicianus*) because of the lack of concealing cover in most prairie dog colonies and the communal defense strategy of the species (see Hoogland 1995). Hoogland (1995) did observe Bobcats preying on prairie dogs on a 6.6 ha colony at Wind Cave National Park (NP) that was bordered by forest. In those instances, Bobcats rushed in from the forest edge to capture prairie dogs (John Hoogland, personal communication). However, most Black-tailed Prairie Dog colonies are located in open grasslands and Bobcats generally avoid large open areas (Anderson and Lovallo 2003). Therefore, the Bobcat's reluctance to use open areas, the lack of concealing cover in most Black-tailed Prairie Dog colonies, and the prey species communal defense strategy suggest that Bobcats may rarely hunt Black-tailed Prairie Dogs and would have difficulty in capturing them. Hoogland (1995: 69) reported that on his way to his study site he observed Bobcats sitting motionless next to prairie dog mounds using what he termed a "sit-and-wait tactic"; however, he did not describe those incidents in detail or the outcomes. In this paper I describe observations of Bobcats hunting Black-tailed Prairie Dogs in western South Dakota.

Methods

In the winter of 2008-09, I and others made several incidental observations of Bobcats hunting Black-tailed Prairie Dogs at Badlands and Wind Cave National Parks in western South Dakota. In the winter of 2009-10, I made a deliberate attempt to observe and document more events in an effort to better understand and describe the Bobcat hunting methods. At both Badlands and Wind Cave National Parks I drove park roads that provided a view of prairie dog colonies in close proximity to Bobcat cover such as broken badlands topography (Badlands NP) or forests (Wind Cave National Park). Once a Bobcat was observed I watched the animal from the vehicle. The animals showed little alarm to the vehicle, perhaps due to the regular presence of vehicles and the prohibition against hunting in the parks. However, some animals did abandon hunts, possibly due to observer presence. Therefore, I only present data from incidents where the Bobcat made a lunge to capture a prairie dog. The Bobcats were not marked and thus positive identification of individual hunting methods was not possible. I did not record information on observer effort (e.g., miles driven, number of observation days) or on Bobcat observations that did not include a lunge at a prairie dog. Several of the observations were videotaped allowing for more detailed and precise description of the events. Distances were determined from remote imagery and GIS software.

TABLE 1. Observations of Bobcats Pouncing at Prairie Dogs.

Site	Date	Start Time of Observation of Bobcat	Time of Bobcat Lunge	Result	Size of Colony (ha)	Distance from Colony Edge (m)	Distance from Forest or Badlands (m)
Wind Cave NP	3/25/09	Crouched at mound at 0822	0936	miss	195	70	130
Badlands NP	3/09	First observed about 0630	About 1400	kill	2.7	25	150
Badlands NP	10/23/09	First observed at 0825	0857	miss	38.8	50	120
Badlands NP	1/16/10	Crouched at mound at about 1150	1159	kill	2.7	30	210
Badlands NP	1/17/10	First observed about 1330	1351	kill	10.9	85	270
Badlands NP	1/30/10	Crouched at mound about 0820	0849	kill	2.7	40	210
Badlands NP	1/30/10	First observed about 1230	1301	miss	5.4	70	100
Badlands NP	2/3/10	Crouched at mound at 0825	0928	kill	38.8	105	140
Badlands NP	2/19/10	Crouched at mound at 1320	1321	kill	5.4	50	130
Badlands NP	2/26/10	First observed at 0920	0920	kill	0.2	15	105
Badlands NP	3/2/10	First observed at 0923	0937	miss	0.1	15	70
Badlands NP	3/4/10	Crouched at mound at 1055	1105	kill	38.8	70	110
Badlands NP	3/13/10	First observed at 0705	0755	kill	0.9	15	30

Results

I recorded 13 observations of Bobcats attempting to ambush prairie dogs as they emerged from their burrow (Table 1). Many other incidents of Bobcats crouching next to prairie dog burrow-mounds were observed, but they did not culminate in a lunge at a prairie dog. All but one of the recorded incidents consisted of a Bobcat pouncing at a prairie dog while the latter was still in the burrow. In the remaining case a Bobcat was crouched next to a prairie dog mound, but pounced at and captured a prairie dog that had walked up behind it. Of the 12 cases in which a Bobcat pounced at a prairie dog in a burrow, eight were successful. In the 13 events reported here the Bobcats were stationed at a prairie dog mounds an average of 49 m (range 15-105) from the edge of the prairie dog colony and 136 m (range 30-270) from badlands topography or forest cover. The 12 events at Badlands National Park occurred on six unique prairie dog colonies, with the farthest distance between events being 7.95 km. Nine of the events were clustered within a 54.1 ha minimum convex polygon. The next closest event was 1.75 km to the east of the polygon and was made by a female Bobcat with kittens. The other two events at Badlands National Park were 2.9 and 4.2 km to the east of that and were likely made by another animal as no kittens were observed with it. Many of the other characteristics of the events are not suitable for quantitative analysis and summary; therefore, I qualitatively describe some of the more noteworthy incidents in chronological order.

At 0822 on 25 March 2009, I observed a Bobcat at Wind Cave NP in southwestern South Dakota. Temperature was 0°C with wind speed about 8 kph. Small patches of drifted snow covered about 10 percent of the colony. No prairie dogs were observed or heard. The Bobcat was walking through the colony when it stopped to inspect a prairie dog mound about 70 m within the colony. The Bobcat then laid down facing the mound. Thirteen minutes later the Bobcat got up and moved to the leeward (north) side of the mound. The Bobcat laid motionless for the next 57 minutes, except for occasionally turning its head to look around. During that period I observed prairie dogs emerging from other burrows in the colony. At 0936 a prairie dog poked its head above the rim of the mound the Bobcat was stationed at. The Bobcat, which had been lying prone on the ground with its head below the top of the mound, sprung for it. When I later analyzed the videotape of the incident I could see the Bobcat react within 0.37 s (+/- 0.017) of the prairie dog poking its head out of the burrow-mound. Within 0.17 s (+/- 0.017) of the first movement by the Bobcat it had one paw in the burrow entrance. The Bobcat's momentum carried its hindquarters over the mound, but it kept a paw in the burrow entrance. After looking into the burrow for three seconds the Bobcat quickly pulled its paw out of the burrow and walked back to the forest without having captured the prairie dog.

In late March 2009, around 0630, a Bobcat was observed laying near a prairie dog mound at Badlands NP (Loyd Griswold, Badlands National Park, personal observation). When the observer returned around 0830 he again saw a Bobcat crouched at the mound. No prairie dogs were observed. When the observer returned to the site at about 1300 he again saw a Bobcat crouched at the same mound, presumably the same individual. The observer noted that prairie dogs had begun emerging from other burrows in the colony. The Bobcat remained crouched at the mound, but its attention focused on several prairie dogs about 15 m away. At the same time another prairie dog approached the Bobcat from behind, evidently unaware of the Bobcat's presence. When the prairie dog was about a meter from the Bobcat the latter turned and saw the prairie dog. The Bobcat sprung and cap-

tured the prairie dog and then held it for about three minutes before carrying it off to some rugged badlands topography. Time of the kill was around 1400. Assuming it was the same Bobcat observed at 0630, and it hadn't moved in the interim, the animal had remained crouched at the mound for at least 7.5 hr.

At 0825 on 23 October 2009, I observed a Bobcat laying next to a prairie dog mound at Badlands National Park. Temperature was 3°C and average wind speed was 17 kph from the WNW. At 0857 the Bobcat lunged toward the burrow and inserted a paw into the burrow entrance, but it did not capture a prairie dog. The Bobcat walked around the mound for a few seconds and then crouched back down at the same mound. At 0909 the Bobcat again prepared to spring at the burrow, but it soon relaxed. At 0954 something spooked the Bobcat and it quickly left the prairie dog colony. I subsequently determined that the azimuth of the burrow opening was 30° from true north and the Bobcat had a bearing of 330° at the time it lunged toward the burrow. In other words, the direction the Bobcat was facing prior to the lunge and the direction the prairie dog was facing (assuming it was walking up the burrow) made a 120° obtuse angle.

Around 0900 on 16 January 2010, I observed a Bobcat laying next to a prairie dog mound at Badlands National Park. Temperature was 3° C and average wind speed was 19 kph from the SW. No prairie dogs were observed in the colony. About one hour later about 12 prairie dogs emerged approximately 40 m from the crouching Bobcat. At about 1100 the Bobcat made a run toward the emerged prairie dogs, but they escaped down their burrows. The run did not appear to be a full speed attempt to catch a prairie dog, but rather, a testing flush or pursuit. The Bobcat inspected the burrow-mounds and then walked about 20 m to a mound at the edge of the colony where it again crouched down. Approximately 15 minutes later five prairie dogs re-emerged from burrows they had escaped to when the Bobcat charged them earlier. The Bobcat remained crouched at the mound watching the prairie dogs for about 30 minutes at which time it made another unsuccessful rush toward the prairie dogs at less than full speed. The Bobcat again inspected the burrows in the vicinity of where the prairie dogs had been. The Bobcat stopped at one mound and peered over the rim of the mound into the burrow. Within a minute of positioning itself at the mound the Bobcat sprung from a standing position and reached into the burrow with its left paw. The Bobcat stuck its head into the burrow entrance and emerged with a prairie dog in its mouth. The Bobcat then carried the prairie dog into the taller vegetation outside the prairie dog colony where it ate the prairie dog. Through the vegetation I could see the Bobcat cover the remains of the prairie dog with snow. I subsequently determined that the direction the Bobcat was facing at the time of the lunge and the direction of the burrow opening (i.e., the direction the prairie dog was likely facing) made a 130° horizontal obtuse angle.

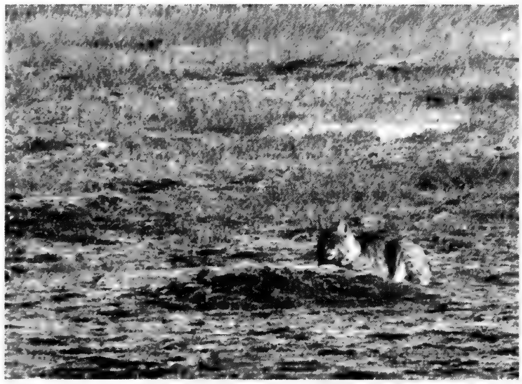


FIGURE 1a. Bobcat waiting next to a Prairie Dog burrow-mound.

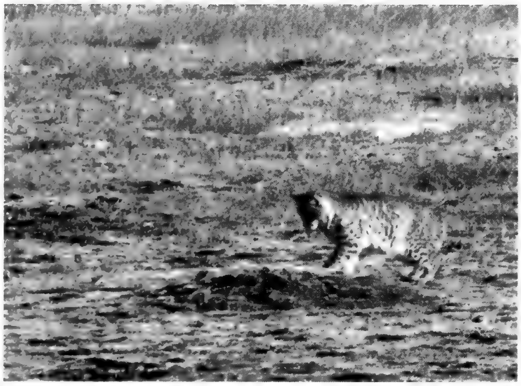


FIGURE 1b. Bobcat inspecting a Prairie Dog burrow-mound, perhaps in response to hearing an emerging Prairie Dog.

At 0820 on 30 January 2010 I observed a Bobcat walking through a prairie dog colony. Temperature was -11°C and average wind speed was 13 kph from the WNW. After inspecting several mounds the Bobcat laid down next to a mound with its head facing the mound (Figure 1a). No prairie dogs were observed. At 0849 the Bobcat stood up and looked into the burrow opening in apparent preparation for a lunge (Figure 1b). I did not observe a prairie dog stick its head above the mound rim nor does it seem that the Bobcat saw a prairie dog based on the height of the mound and the height of the Bobcat's head while it was lying down. Presumably, the Bobcat was responding to either sound or odor. The Bobcat then crouched in a springing position (Figure 1c). At 0850 the Bobcat pounced toward the burrow entrance and pulled out a prairie dog (Figures 1d, 1e). The Bobcat carried the prairie dog to some taller vegetation outside the colony perimeter where it ate the prairie dog. No other prairie dogs were yet

observed in the 2.7 ha colony. I subsequently determined that the direction the Bobcat was facing at the time of the lunge and the direction of the burrow opening made a 140° horizontal obtuse angle.

At 0825 on 3 February 2010 I observed a Bobcat walking through a prairie dog colony. The Bobcat inspected a mound and then crouched down next to it. A short time later the Bobcat sat up and watched a Coyote (*Canis latrans*) walk past about 100 m away. Shortly after the Coyote passed by the Bobcat crouched back down. At 0928 the Bobcat raised up on its front legs and then sprung forward and captured a prairie dog.

At 0843 on 19 February 2010, I observed a Bobcat lying prone next to a prairie dog mound at Badlands National Park. No prairie dogs were observed. About 30 minutes later a prairie dog gave the alarm call from a mound about 15 m from the Bobcat (I had not seen the prairie dog emerge). The Bobcat got up, stretched, and then walked over to the mound where the prairie dog had called from. The Bobcat hunched next to the burrow-mound the prairie dog had escaped down. I observed the Bobcat from 0843 to 1321 except for a break of approximately 1 hour; I observed the Bobcat move to and crouch down next to at least 9 different mounds, all apparently in response to seeing a prairie dog escape down a burrow. At 1320 the Bobcat hurriedly left the mound it was stationed at and moved to a mound about 5m away. The Bobcat did not lie down next to the mound, but rather, it stood next to the mound in preparation for a lunge. Approximately, one minute after arriving at the mound the Bobcat pounced and retrieved a prairie dog from the burrow.

At 0730 on 26 February 2010, I observed a Bobcat lying prone next to a prairie dog mound at Badlands NP. Temperature was -1°C and average wind speed was 16 kph from the W. No prairie dogs were observed. About 1 hour later a prairie dog called out from a mound about 15 m away. The Bobcat abandoned the mound it was at and walked over to the mound which the prairie dog had escaped to. The Bobcat position itself at that mound. The Bobcat subsequently moved to three other mounds; the moves appeared to be in response to calling prairie dogs. At 0920 the Bobcat pounced at the mound and captured a prairie dog. I subsequently determined that the direction the Bobcat was facing prior to the lunge and the direction of the emerging prairie dog made a 150° obtuse angle.

At 0705 on 13 March 2010, I observed a Bobcat lying prone next to a prairie dog mound at Badlands NP. No prairie dogs were observed; however, a Cottontail Rabbit was observed at a burrow entrance about 30 m from the Bobcat. About 0730 a prairie dog emerged from a burrow about 25 m from the Bobcat, but it retreated back down the burrow a few minutes later. At 0755 the Bobcat sprung from the prone position and captured a prairie dog from the burrow-mound it was stationed at. In contrast to all of the other kills reported here, that Bobcat stayed at the mound with the captured prairie dog for about 10 minutes. During that time the Bobcat looked around attentively, including looking at the observer parked in a car about 50 m away. It then carried the prey off to some badlands topography.

FIGURE 1c. Bobcat in lunging position.

Discussion

The lack of concealing cover in Black-tailed Prairie Dog colonies, and the communal defense strategy of the species, would seem to make Bobcat predation of prairie dogs a rare event. However, some Bobcats use an ambush strategy to capture prairie dogs emerging from their burrows. In some cases the Bobcats positioned themselves in a colony prior to prairie dog emergence; in other cases Bobcats positioned themselves next to a burrow a prairie dog had just escaped down. The fact that I observed both methods on the same prairie dog colony suggests that individual Bobcats may use both methods depending on conditions. The Bobcats position themselves at an acute oblique angle to the emerging prairie dog, i.e., they attack from the front and to the side of the emerging prairie dog. Bobcats appear to use sound to prepare themselves for the lunge, but it is unknown whether they lunge in response to sound or sight.

I have observed Bobcats crouched next to prairie dog mounds at Badlands and Wind Cave National Parks on numerous, but unrecorded occasions in addition to the observations reported here, but in those incidents the Bobcats gave up on the mounds, were spooked by the observer, or abandoned the mound for unknown reasons, hence I do not present information on those events. Also, individual Bobcats were not identifiable, so I cannot describe the frequency that individual Bobcats visited the prairie dog colonies nor can I attribute hunting strategies to different animals. However, based on seeing Bobcats at the same colonies on almost every trip to Badlands National Park in the winter of 2009-10, it appears that some

FIGURE 1d. Bobcat lunging at Prairie Dog.

FIGURE 1e. Bobcat with Prairie Dog.

Bobcats were making almost daily hunting forays into the prairie dog colonies and had become quite proficient at capturing prairie dogs. The cluster of nine events within a 54.1 ha polygon suggests that one individual was responsible for all the events. One of the other events was made by a female Bobcat that brought the kill to her young. There is some evidence that young Bobcats may learn this tactic from their mother. On 30 December 2008, around sunrise, four Bobcats (likely an adult female and three kittens based on the size) were observed in a prairie dog colony at Badlands National Park (Joshua Delger, Badlands National Park, personal observations). All four were within 100 m of each other and three were crouched at separate mounds while the fourth was sitting near the edge of the colony.

The observations reported here occurred in late-fall and winter. On only one occasion have I observed a Bobcat crouched next to a prairie dog mound at Badlands and Wind Cave National Parks in spring, summer, or early fall. Similarly, law enforcement rangers at Badlands National Park conduct daily patrols of the sites where the Bobcat observations reported here were made and they rarely observe Bobcats outside of winter (Loyd Griswold, personal communication). In spring, summer, and early fall there is more prey available to Bobcats, including young and naïve individuals. Thus, Bobcats may hunt more vulnerable prey during those periods. Perhaps just as importantly, Bobcats may also switch to habitats with more cover to reduce their risk of predation or interference by Coyotes (Fedriani et al. 2000). However, another possibility is that there is much less vehicle traffic in the winter and therefore the Bobcats may be more willing to hunt the prairie dog colonies along the road.

In several of the cases reported here, and in numerous other cases that did not culminate in a pounce, I observed Bobcats entering a prairie dog colony prior to prairie dog emergence. The Bobcats would typically inspect several mounds before crouching down next to a mound in a waiting position. The number of Black-tailed Prairie Dog burrow entrances in a colony may be eight times greater than the number of prairie dogs, and prairie dogs share burrows overnight (see Hoogland 1995). Therefore, if a Bobcat randomly selected a mound to crouch next to, the odds would be against it selecting an occupied burrow. The Bobcats I observed clearly inspected burrow-mounds prior to crouching next to the mound. In one case the Bobcat captured a prairie dog when no other animals had yet emerged for the day and in another case the Bobcat captured a prairie dog when only one other animal had emerged in the colony, suggesting that Bobcats may be able to select a burrow with prairie dogs in it. Licht (2009) observed a Badger that inspected several prairie dog burrow entrances before excavating a burrow that had a prairie dog in it. However, in other cases prairie dogs did emerge from other burrows in the colony while the Bobcat waited unsuccessfully at the mound it was crouched next to. I cannot say whether the burrows that unsuccessful Bobcats were crouched next to were vacant, whether the prairie dogs suspected the Bobcat was near the entrance, or whether those prairie dogs simply did not emerge during the observation period.

The Bobcat is a widely distributed species that occupies many habitats and feeds on a variety of prey (Anderson and Lovallo 2003). Throughout the Bobcat's range the prairie dog is unlikely to comprise a large component of the diet. Anderson and Lovallo (2003) and Hansen (2007) reviewed and summarized the Bobcat's diet and did not mention prairie dogs. However, almost all of the studies they cited were from areas that do not contain prairie dogs. Young (1958) reported that prairie dog remains constituted only 0.6% of the 3990 remains found in Bobcat stomachs from animals collected in 1918-1922; however, those results also appear to be biased towards regions without prairie dogs. Gashwiler et al. (1960) found White-tailed Prairie Dog (*C. leucurus*) remains in 1 of the 53 Bobcat stomachs they analyzed in Utah and Nevada, but they did not document the availability of prairie dogs in the region. Nomsen (1982) found Black-tailed Prairie Dog

remains in 1% of male Bobcats and 3% of female Bobcats collected in western South Dakota (n = 230); however, much of that region is devoid of prairie dogs. Based on my observations in western South Dakota at sites with broken terrain or woody cover in close proximity to prairie dog colonies, prairie dogs may represent a comparatively large portion of the winter diet of Bobcats.

Acknowledgments

I thank Cory Mosby, Joshua Delger, Dan Roddy, Loyd Griswold, and John Hoogland for contributing information and for reviewing the manuscript.

Literature Cited

Anderson, E. M., and **M. J. Lovallo.** 2003. Bobcat and lynx (Lynx rufus and Lynx Canadensis). Pages 758-788 *in* Wild mammals of North America: biology, management, and conservation. *Edited by* G. A. Feldhamer, B. C. Thompson, and J. A. Chapman. The John Hopkins University Press, Baltimore Maryland. 1216 pages.

Biggins, D. E., and **D. M. Biggins.** 2006. Bobcat attack on a cottontail rabbit. The Southwestern Naturalist 51: 119-122.

Fedriani, J. M., T. K. Fuller, R. M. Sauvajot, and **E. C. York.** 2000. Competition and intraguild predation among three sympatric carnivores. Oecologia 125: 258-270.

Gashwiler, J. S., W. Leslie Robinette, and **O. W. Morris.** 1960. Foods of bobcats in Utah and Eastern Nevada. Journal of Wildlife Management 24: 226-229.

Hansen, K. 2007. Bobcat: master of survival. Oxford University Press, New York. 212 pages.

Hoogland, J. L. 1995. The black-tailed prairie dog: social life of a burrowing mammal. The University of Chicago Press, Chicago. 557 pages.

Jacques, C. N., and **J. A. Jenks.** 2008. Visual observation of bobcat predation on an adult female pronghorn in northwestern South Dakota. American Midland Naturalist 160: 259-261.

Johnsgard, P. A. 2005. Prairie dog empire. University of Nebraska Press, Lincoln. 243 pages.

Licht, D. S. 2009. Observations of badgers preying on black-tailed prairie dogs. Prairie Naturalist 41: 134-136.

Nomsen, D. 1982. Food habits and placental scar counts of bobcats in South Dakota. M.S. thesis, South Dakota State University, Brookings. 38 pages.

Young, S. P. 1958. The bobcat of North America. The Wildlife Management Institute, Washington, D.C. 193 pages.

Received 14 April 2010
Accepted 21 October 2010

Prolonged Intensive Dominance Behavior Between Gray Wolves, *Canis lupus*

L. DAVID MECH[1,2] and H. DEAN CLUFF[3]

[1] U.S. Geological Survey, Northern Prairie Wildlife Research Center, 8711 – 37th Street SE, Jamestown, North Dakota 58401-7317 USA

[2] Mailing address: The Raptor Center, 1920 Fitch Avenue, University of Minnesota, St. Paul, Minnesota 55108 USA; e-mail: david_mech@usgs.gov

[3] Government of the Northwest Territories, Department of Environment and Natural Resources, P.O. Box 2668, Yellowknife, Northwest Territories X1A 2P9 Canada; e-mail: dean_cluff@gov.nt.ca

Mech, L. David, and H. Dean Cluff. 2010. Prolonged intensive dominance behavior between Gray Wolves, *Canis lupus*. Canadian Field-Naturalist 124(3): 215–218.

Dominance is one of the most pervasive and important behaviors among wolves in a pack, yet its significance in free-ranging packs has been little studied. Insights into a behavior can often be gained by examining unusual examples of it. In the High Arctic near Eureka, Nunavut, Canada, we videotaped and described an unusually prolonged and intensive behavioral bout between an adult male Gray Wolf (*Canis lupus*) and a male member of his pack, thought to be a maturing son. With tail raised, the adult approached a male pack mate about 50 m from us and pinned and straddled this packmate repeatedly over 6.5 minutes, longer than we had ever seen in over 50 years of studying wolves. We interpreted this behavior as an extreme example of an adult wolf harassing a maturing offspring, perhaps in prelude to the offspring's dispersal.

Key Words: Gray Wolf, *Canis lupus*, behavior, dispersal, dominance behavior, harassment, parent-offspring conflict, Arctic, Nunavut, Canada.

Dominance is one of the most pervasive and important behaviors among Wolves in a pack (Schenkel 1947; Packard 2003), and much has been written about it in captive wolves (Schenkel 1947, 1967; Zimen 1982; Van Hoof and Wensing 1987). However, there is a dearth of published information about dominance behavior in free-ranging wolves, especially descriptions, context, and quantification. Dominance behavior can include a broad spectrum of social interactions from a parent wolf chastising a young pup to full-fledged battles (Mech 1993), sometimes resulting in death. In our experience, the most usual context of dominance behavior in free-ranging wolves is that of parent to offspring. However in the few free-ranging wolf packs observed closely enough, no one has quantified or even described parent-offspring dominance behavior (Murie 1944; Clark 1971; Haber 1977; Mech 1997). We observed and videotaped an unusual, prolonged and intensive bout of such behavior by an adult male Gray Wolf, *Canis lupus*, and a male member of his pack thought to be a maturing son. Because of the unusually persistent and intensive nature of this interaction we document it here.

Study Area and Methods

During summers 1986-2009, LDM and assistants studied Gray Wolves in the Eureka area of Ellesmere Island (80°N, 86°W), Nunavut, Canada, especially behavioral interactions among pack members and their dens (Mech 1997, 1999, 2000). The area is barren and has no trees. Wolves prey mostly on Muskoxen (*Ovibos moschatus*) and Arctic Hares (*Lepus arcticus*). From at least 1986 through 1997, a pack of 3–7 adult wolves produced pups almost annually in traditional dens in the area and again from 2004-2009. The wolves were unafraid of humans, so we could observe them from as close as 1 m and also follow them on all-terrain vehicles (ATVs) (Mech 1994). We used binoculars, a spotting scope, and video cameras to aid our observations. During summers 2003-2006, the pack was led by a large, bold, and all-white, male wolf that did raised-leg urinations (RLUs), a sign of dominance (Harrington and Asa 2003). From 2004 through 2006 we observed this wolf's pack with pups around a den, but in 2007 and 2008, no pack denned in the study area. However in August 2007, local weather station personnel observed a pack with pups that visited the area for a few days, along with the large, bold, all-white male. Although we could not document that animal's presence in 2008 when we documented an active den at least 20 km away (Mech and Cluff 2009), we believe we encountered that wolf in 2009 as a member of a pack of at least 12 adults plus pups.

At 1600 h on 8 July 2009, we darted via blowgun a 41.5-kg male Wolf with 10 mg Telazol™/kg, estimated his age at about 9 years based on tooth wear (Gipson et al. 2000), and attached a Telonics™ GPS/Argos/VHF radio collar. (Mention of brand names does not constitute endorsement by the U.S. government.) Based on his size, coat color, boldness, and age, we concluded that this Wolf was the bold male we had observed most years since 2003. When we encountered this wolf, before darting him he was with 4 others and was intensively dominating another wolf. When

we darted him his packmates remained in the immediate area until he recovered and left. We finished processing the wolf at about 1645 h and then observed him and his associates for the next 7.5 hr as he recovered, interacted with packmates, and traveled some 22 km toward the pack's den. On all-terrain vehicles (ATVs), we followed the wolves and observed and videotaped their behavior.

Results

At 1930 hr, the radioed wolf appeared fully recovered and was able to walk normally upslope. At 2120 hr, he stood over (Mech 2001) a packmate assumed to be a male (Schenkel 1947), and pinned him (Goodman and Klinghammer 1990) about 50 m from us. During the next 6.5 minutes, the radioed wolf with tail vertical, stood over (Figure. 1), pinned (Figure 2), or held the other Wolf down (Figure. 3), or by straddling (Figure 4) or riding up (Figure 5) on it (Goodman and Klinghammer 1990) forced it down (Figure 6) for almost all of the 6.5 min. See http://www.youtube.com/watch?v=wIRVpLaCDS0.

Although the 6.5 minutes of videotaped domination was the longest period of this type of interaction we observed during the 7 hr and 45 minutes that we watched this pack that day, it was only one of several such times we saw the radioed wolf behave similarly, including the time before we darted him. This domination was also directed towards at least two of the other four wolves in the group. (Note: the pack contained ≥ 12 adults including the collared male and ≥ 3 pups, all observed by homing in on the collared male by helicopter on 15 July.)

Discussion

Dominant wolves, which are usually the adult parents of the pack (Mech 1999) commonly dominate offspring by forcing them to the ground. We have found no literature documenting how long such interactions typically last, but in our experience observing wolves over a 50-year period and close up during many summers (Mech 1993, 1997, 1999, 2000), such behavior generally ends in less than 30 seconds. Domination usually ends when the subjugated wolf jumps up. During the 6.5-min bout that we videotaped, the dominant animal forced the other back down each time it tried to rise.

All of our observations of this dominating behavior by the radioed wolf were made after we had drugged and radio-tagged him. Conceivably the length, persistence, and intensity of the behavior could be related to our handling him. However, when we first observed this wolf before darting him he was dominating one of his packmates intensively. We only observed this for about 10 seconds, for our approach interrupted that activity. However we believe that that incident is strong evidence that the observation we report here

FIGURE 1. A dominant, breeding male wolf stands over a subordinate on Ellesmere Island, Nunavut, Canada during July 2009.

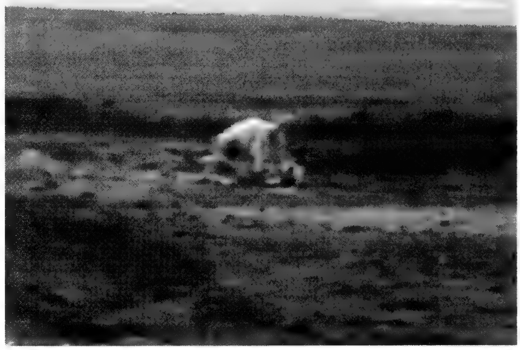


FIGURE 2. A dominant, breeding male wolf pins a subordinate on Ellesmere Island, Nunavut, Canada during July 2009.

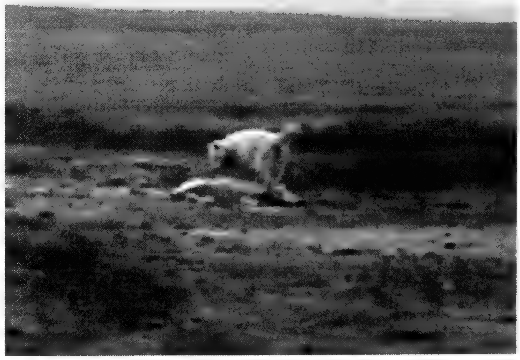


FIGURE 3. A dominant, breeding male wolf holds down a subordinate on Ellesmere Island, Nunavut, Canada during July 2009.

FIGURE 4. A dominant, breeding male wolf straddles a subordinate on Ellesmere Island, Nunavut, Canada during July 2009.

FIGURE 5. A dominant, breeding male wolf rides up on a subordinate on Ellesmere Island, Nunavut, Canada during July 2009.

FIGURE 6. A dominant breeding male wolf forces a subordinate wolf down on Ellesmere Island, Nunavut, Canada during July 2009.

was merely a continuation of his normal behavior, not a consequence of the drugging. However, even if the behavior had been affected by the drugging, this observation still is of interest, for no one has reported such prolonged dominating under any circumstance.

A possible explanation for the behavior we report is that it represents domination on the part of a parent wolf toward a maturing offspring that eventually leads to the dispersal of that offspring. Although pre-dispersal harassment of this length and intensity within a pack has not been documented before, frequent chasing of individual wolves attempting to remain, follow, or join wolf packs is not uncommon (Mech 1966), and actual fights between parent and same-sex offspring in captivity have been reported (Packard et al. 1985). All these observations including ours would fit a hypothesis that adult wolves sometimes harass maturing offspring until they leave the pack and disperse.

Acknowledgments

This research was funded by the U.S. Geological Survey. Atmospheric Environment Sciences of Canada and Polar Continental Shelf Project provided logistical support. C. Asa, F. Harrington, J. Way, and an anonymous referee suggestsed comments that improved the manuscript. This is PCSP/EPCP paper 05009.

Literature Cited

Clark, K. R. F. 1971. Food habits and behavior of the tundra wolf on central Baffin island. Ph.D. thesis. University of Toronto, Toronto, Ontario, Canada.

Gipson, P. S., W. Ballard, W. B. Nowak, R. M. Nowak, and **L. D. Mech.** 2000. Accuracy and precision of estimating age of gray wolves by tooth wear. Journal of Wildlife Management 64: 752-758.

Goodmann, P. A., and **E. Klinghammer.** 1990. Wolf ethogram. Ethology Series Number 3. North American Wildlife Park, Battle Ground, Indiana.

Haber, G. C. 1977. Socio-ecological dynamics of wolves and prey in a subarctic ecosystem. Ph.D. thesis. University of British Columbia, Vancouver, British Columbia, Canada. 824 pages.

Harrington, F. H., and **C. S. Asa.** 2003. Wolf communication. Pages 66-103 *in* Wolves, behavior, ecology, and conservation. *Edited by* L. D. Mech and L. Boitani, University of Chicago Press, Chicago, Illinois.

Mech, L. D. 1966. The Wolves of Isle Royale. National Parks Fauna Series Number 7. U.S. Government Printing Office. 210 pages (Reprinted 2002. University of the Pacific, Honolulu, Hawaii).

Mech, L. D. 1993. Details of a confrontation between two wild wolves. Canadian Journal of Zoology 71: 1900-1903.

Mech, L. D. 1994. Regular and homeward travel speeds of arctic wolves. Journal of Mammalogy 75: 741-742.

Mech, L. D. 1997. The Arctic wolf: Ten years with the pack. Voyageur Press, Stillwater, Minnesota. 144 pages.

Mech, L. D. 1999. Alpha status, dominance, and division of labor in wolf packs. Canadian Journal of Zoology 77: 1196-1203.

Mech, L. D. 2000. Leadership in wolf, *Canis lupus*, packs. Canadian Field-Naturalist 114: 259-263.

Mech, L. D. 2001. Standing over and hugging in wild wolves. Canadian Field-Naturalist 115: 179-181.

Mech, L. D., and **H. D. Cluff.** 2009. Long daily movements of wolves (*Canis lupus*) during pup rearing. Canadian Field-Naturalist 123: 68-69.

Murie, A. 1944. The wolves of Mount McKinley. U.S. National Park Service Fauna Series Number 5. U.S. Government Printing Office, Washington, D.C.

Packard, J. M., U. S. Seal, and **L. D. Mech**. 1985. Causes of reproductive failure in two family groups of wolves (*Canis lupus*). Zeitschrift fur Tierpsychology 68: 24-40.

Packard, J. M. 2003. Wolf behavior: reproductive social, intelligent. Pages 35-65 *in* Wolves, behavior, ecology, and conservation. *Edited by* L. D. Mech and L. Boitani, University of Chicago Press, Chicago, Illinois.

Schenkel, R. R. 1947. Ausdrucks-studien an wolfen [Expression studies of wolves]. Behaviour 1:81-129. [translation from German by F. Harrington].

Schenkel, R. R. 1967. Submission: Its features and function in the wolf and dog. American Zoology 7: 319-329.

Van Hooff, J. A. R. A. M., and **J. A. B. Wensing**. 1987. Dominance and its behavioral measures in a captive wolf pack. Pages 219-252 *in* Man and wolf: Advances, issues, and problems in captive wolf research. *Edited by* H. Frank. Dr. W. Junk Publishers, Dordrecht, The Netherlands.

Zimen, E. 1982. A wolf pack sociogram. Pages 282-322 *in* Wolves of the world. *Edited by* F. H. Harrington and P. C. Paquet. Noyes Publication, Park Ridge, New Jersey.

Received 18 April 2010
Accepted 29 October 2010

Productivity of Ospreys, *Pandion haliaetus,* Affected by Water Levels Near Loon Lake, Saskatchewan, 1975–2002

C. STUART HOUSTON[1], FRANK SCOTT[2], and ROB B. TETHER[3]

[1] 863 University Drive, Saskatoon, Saskchewan S7N 0J8 Canada; E-mail: stuart.houston@usask.ca
[2] Box 2, GS 317, Saskatoon, Saskatchewan S7K 3J6 Canada
[3] Department of the Environment, Unit 1, 101 Railway Place, Meadow Lake, Saskatchewan S9X 1X6 Canada

Houston, C. Stuart, Frank Scott, and Rob B. Tether, 2010. Productivity of Ospreys, *Pandion haliaetus,* affected by water levels near Loon lake, Saskatchewan, 1975-2002. Canadian Field-Naturalist 124(3): 219–224.

Between 1975 and 2002, diminished breeding success of Ospreys was associated with drought and falling lake levels in the western half of our study area near the town of Loon Lake, west-central Saskatchewan. Only 46% of nest attempts were successful in the west compared to 72% in the east, producing 0.88 young per accessible nest in the west and 1.42 in the east. Breeding success was greater in the eastern half, where water levels were stable, in spite of increased human use of the resort lakes there. Our unique long-term Canadian data base results support Ogden's 1977 prediction that Osprey productivity may decrease when water levels drop and fish populations are reduced.

Key Words: Osprey, *Pandion haliaetus,* clutch size, nest success, artificial nest structures, lake water levels, fish populations, Saskatchewan.

Between 1975 and 2002, 463 nestling Ospreys (*Pandion haliaetus*), a species that relies on fish as food, were raised in summer cottage country near Loon Lake, Saskatchewan. The banding study, which detailed the travels of both adult and young Ospreys, has been published (Houston and Scott 2007).

Methods

Study Area

Our Loon Lake study area encompassed 14 named lakes, several smaller water bodies and two First Nation reserves, near the northern ends of highways 21 and 26 in western Saskatchewan (Figure 1) (Scott and Houston 1985, Houston and Scott 2007). Osprey nest occupancy was determined by aerial surveys of adults in an incubation posture during the last week of May or the first week of June, augmented from 1975 through 1990 by weekly flights from Loon Lake to a medical clinic at the Ministkiwan First Nation.

The area and maximum depth of each major lake was determined by Saskatchewan Fisheries Branch employees in 1973 and 1974, with one-time maps of sounding depths throughout each lake (Table 1). Fish populations were sampled then and at roughly 4-year intervals until 1994, using test nets – for example, a 360 m gill net consisted of 6–60 m gangs, 3.8 to 14.0 cm meshes, set in depths ranging from 1.8 to 15.7 m (Dunn 1985*, Durbin 1981-83*, Snell 1973-79*, Twanow 1986-95*, Wallin 1974-83*).

Hydrology of the two areas is different. A small channel, Ministikwan Creek, that contained no runoff in the years of our study, had the potential in wet years to drain Ministikwan Lake and Branch Lake northeastward into Makwa Lake. The Boa Swamp – Murphy Lake – Fowler Lake chain had water levels maintained by a beaver dam until 1996. The other lakes in the western half drained to the south via Monnery Creek towards the North Saskatchewan River. Together, the western lakes had a small catchment area; most years, evaporation exceeded inflow. The Makwa Lakes in the eastern half of the study area, in contrast, have a larger catchment area, drainage is via the Loon River to the east, and water levels are maintained by the dam on the outlet of the lake into Loon River.

Terminology Regarding Osprey Reproduction

Terminology is based on Postupalsky (1974, 1989) and Steenhof and Newton (2007), with two modifications to allow for less complete surveillance during the incubation period and late fledgling period. A "nest-year" is a nest (territory) occupied in a given year. A nest was successful if one or more young hatched. The term "inaccessible nests" is necessary in Saskatchewan since, unlike Michigan where 97% of the nestlings could be safely accessed (Postupalsky 1989), up to 21% of Saskatchewan trees (in 1982-88, see Table 3) were unsafe to climb — and the nestlings in them could not be counted accurately from an airplane. Known causes of nest failure included unhatched (some infertile) and broken eggs, death of all young, starvation, predation, desertion, and nest destruction by high winds. A single annual climb to each accessible nest when the young were two-thirds to four-fifths grown, the age at which most young are banded (Steenhof and Newton 2007), determined the number of nestlings. We calculated the number of young per successful nest and the number per accessible nest, the latter figure including nests that had failed.

Construction of Nest Platforms

To reduce the high number of inaccessible nest trees, we replaced some of them with platforms during 11 weekends in late March or very early April in 1975,

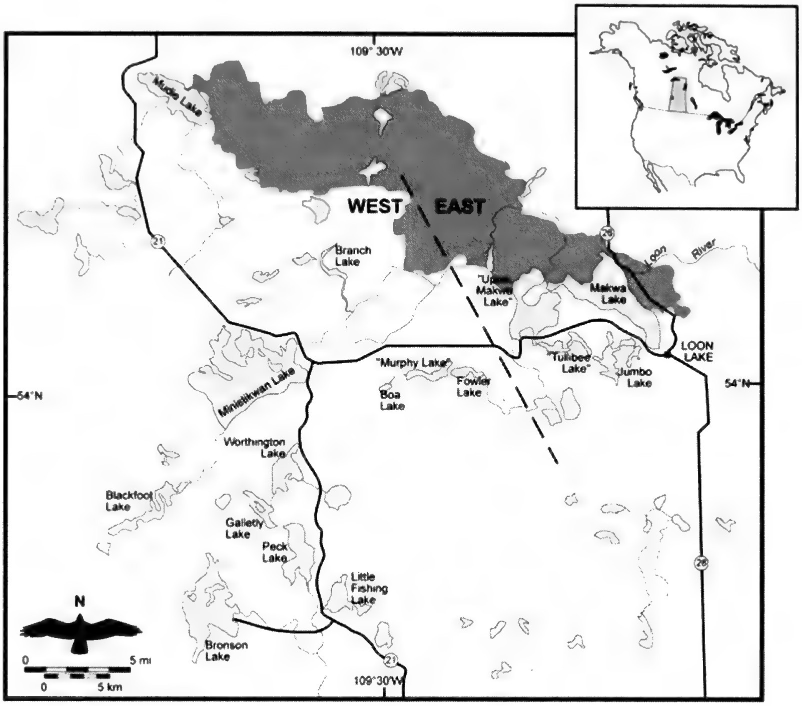


FIGURE 1. Loon Lake area, showing lakes and the demarcation between the West and East components of the area, and the extent of the Mudie Lake fire in 2002. Map by Carol Beaulieu.

1983 to 1990, 1992, and 1994. We felled both dead and live nest trees deemed likely to fall during high winds and then placed the nest contents on the adjacent newly-built platform in a neighbouring tree (Scott and Houston 1985; Houston and Scott 1992, 2007).

Results

Water levels and fish populations

In 1975, water levels were high throughout the entire study area. Through 1977, Ministikwan Lake (in the west half of the region and the largest lake in the region), had a thriving winter commercial whitefish harvest of 12,000 to 15,000 kg/yr (Anonymous 1962, 1973*). For those three years, the western portion of the study area contained the only known occupied and accessible Osprey nests. The first water level decline became evident in 1987 when we could not reach Galletly Lake by boat since the stream from there to Peck Lake had dried up. From 1981 to 1983 there was a poor spring run-off and the level of Ministikwan Lake dropped 45 cm in 1983 alone (Harrison 1983*). By 1988, the large slough west of Galletly Lake no longer held sufficient water for Frank Scott's float plane to land; in 1990 this large slough was totally dry. At Peck Lake, the commercial whitefish winter fishery was restricted to one month in 1986 and cancelled entirely in 1989, the year that lake levels had dropped 2.8 m (Twanow 1993a*).

As a consequence, whitefish, walleye and pike populations dropped appreciably. By 1988 few large whitefish remained in Ministikwan Lake, so the commercial harvest that winter was limited to 4500 kg, only one-quarter of earlier peak levels, and the daily catch for sport fishing anglers was cut in half from 8 to 4 per day – and has never been restored (Twanow 1988a). In 1987 and 1994, winter-kills of fish occurred in Galletly Lake, the 1994 kill-off being total (Twanow 1994a*). Similar winter fish-kills were reported at Worthington Lake in 1971 and again in 1987-1990, when winter Dissolved Oxygen levels dropped to 1.7 ppm (Twanow 1990a*). At Little Fishing Lake the winter whitefish harvest ceased in 1988 (Twanow 1994b*). At Ministikwan Lake, the 1999 and 2000 seasons were closed early because so few whitefish were being caught; there has been no commercial fishing since (RT).

Osprey Productivity

a. Clutch Size. Eggs were counted in 42 nests during 4 years: 1988 (June 4 & 5), 1989 (June 3 & 4), 1990 (June 2 & 3) and 1993 (May 29), while trapping adults at selected occupied nests, both west and east, late in incubation when clutches were complete. One

TABLE 1. Productivity of Ospreys per individual lake in the Loon Lake study area.

West Area	Area (ha)	max depth (m)	total occup nestyrs	access occup' nest/yrs	nestyrs success	# yg banded	yg/ success nestyr	yg/ access nestyr	final yr of use
Ministikwan Lake	2554	25.6	100	77	26	54	2.08	0.70	2000
Bronson Lake†	1000	1.8	10	8	0	0			1989
Blackfoot Lake†	750	1.8	2	2	0	0			1991
Peck Lake	737	14.1	54	50	32	61	1.91	1.22	2000
Worthington Lake	479	7.9	21	21	4	8	2.00	0.38	1991
Little Fishing Lake	394	29	13	13	10	17	1.70	1.31	2000
Branch Lake	300	21	34	34	25	53	2.12	1.56	1998
Galletly Lake & slough†	232	7.6	18	16	6	10	1.67	0.63	1988
Murphy (Hoffman) L	204	6.7	6	3	2	4	2.00	1.33	1992
Fowler Lake	130	8.2	7	6	2	4	2.00	0.67	1990
Moonshine Lake†	30	1.8	4	3	1	1	1.00	0.33	1996
Monnery Creek†	20	1.8	1	1	0	0			1989
Boa Swamp†	20	0.8	17	12	4	4	1.00	0.33	2001
WEST SUMMARY	6780		287	246	112	216	1.93	0.88	
EAST AREA									
Makwa Lake east	1847	23.8	115	105	68	124	1.82	1.18	2002ff
Makwa Lake west	1203	26.5	35	31	26	53	2.04	1.71	2002ff
Jumbo Lake	771	14.6	24	13	10	24	2.40	1.85	2002ff
Tullibee Lake	259	16.8	25	25	21	46	2.19	1.84	2002ff
EAST SUMMARY	4080		199	174	125	247	1.98	1.42	
GRAND SUMMARY	10860		486	420	237	463	1.97	1.10	

† indicates smaller water-bodies not used for fishing; depths and areas are approximate

TABLE 2. Summary of reproductive success, comparing the western and eastern halves of the study area with Postupalsky's larger Michigan study (Postupalsky 1989).

			Successful nests				
	Number accessible attempts	Number Failed nests	Number Success nests	Percent Success	Number Young banded	Yng/nest attempt	Yng/ success nest
West	246	134	112	46%	216	0.88	1.93
East	174	49	125	72%	247	1.42	1.98
Total	420	183	237	56%	463	1.10	1.95
Michigan (Postupalsky)	623	253	370	59%	792	1.27	2.14

TABLE 3. Osprey success by seven-year periods.

	1975-81	1982-88	1989-95	1996-2002	Total
WEST AREA					
Unsafe nest-years	11	25	4	1	41
Failed nest-years	33	58	31	12	134
Accessible nest-years	67	93	63	23	246
Successful nest-years	34	35	32	11	112
% nest success	51%	38%	51%	48%	46%
Young banded	65	69	62	20	216
Yg/successful nest	1.91	1.97	1.94	1.82	1.93
Yg/accessible nest	0.97	0.74	0.98	0.87	0.88
EAST AREA					
Unsafe nest-years	1	17	1	6	25
Accessible nest-years	10	42	58	64	174
Failed nest-years	3	11	14	21	49
Successful nest-years	7	31	44	43	125
% nest success	70%	74%	76%	67%	72%
Young banded	18	59	89	81	247
Yg/successful nest	2.57	1.90	2.02	1.88	1.98
Yg/accessible nest	1.8	1.40	1.53	1.27	1.42

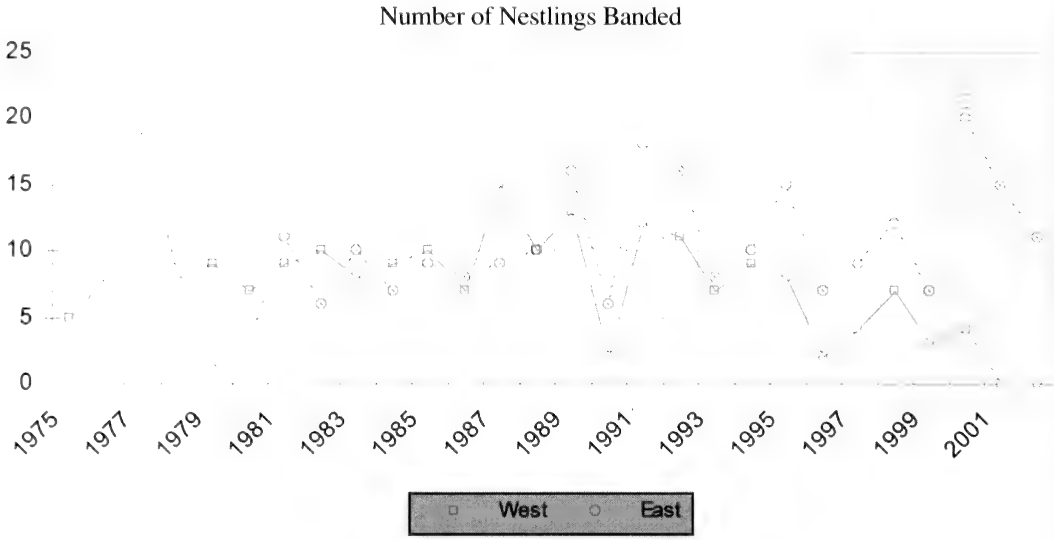


FIGURE 2. Number of successful nests, 1975-2002. In Figures 2 and 3, Squares, joined by solid lines, depict numbers (112 nests, 216 young) in the west half of the Loon Lake study area. Circles, joined by dotted lines, depict the numbers (125 nests, 247 young) in the east half. West: significant decrease over the time of observation, slope = -0.138, $R^2 = 0.305$, $p = 0.002$; East: significant increase over the time of observation, slope = +0.208, $R^2 = 0.504$, $p < 0.00001$.

(2%) had 1 egg, 7 (17%) had 2 eggs, 31 (74%) had 3 eggs, and 3 (7%) had 4 eggs (mean, 2.8 eggs per clutch). Since 1.95 young in an average nest survived to banding age in mid-July, by using the figure of 2.8 eggs per clutch, we calculated that only about 70% of the eggs laid resulted in young that survived to banding age.

b. Percent successful nest attempts. There were 246 accessible nest-years in the western half and 174 in the eastern half (Table 1). Only 46% of nest attempts were successful in the west compared to 72% in the east (Table 2). [Constructed platforms had a 52% success rate in the west (23 of 44 attempts on 7 platforms) but 72% in the east (73 of 101 attempts on 10 structures).] The number of successful nests decreased over the period of observation in the west (R^2 for trend = 0.305, $p = 0.002$). However the number of successful nests in the east increased over the same time (R^2 for trend = 0.504, $p < 0.00001$) (Figure 2).

c. Number of young per accessible nest. In the western half, 0.88 young per accessible nest was far below the 1.42 in the eastern half. Even in the more successful eastern area, the number of young per nesting attempt decreased irregularly over the four 7-year periods, from 1.8 to 1.27 (Table 3). The total number of young banded decreased over the years of observation in the West (R^2 for trend = 0.280, $p = 0.004$). The total number banded in the east increased over the years of observation (R^2 for trend = 0.320, $p < 0.003$).

Discussion

Ogden (1977) suggested that Ospreys are sensitive to habitat quality and should, therefore, make good biological indicators. This hypothesis was tested by Poole (1982) who found that Florida Osprey nests received 43% and 11% fewer fish per day than nests in the two New York colonies, perhaps in part because latitude and season restricted day length and thus foraging time for winter-breeding Florida Ospreys. Bowman et al. (1989) confirmed that the reproductive success of Florida Bay Ospreys after hatching, due to insufficient food resources, was lower than that of birds nesting on adjacent mainline keys, although clutch size was similar. In our Saskatchewan study, we noted that diminishing water levels and decreased fish populations were associated with drastic reductions in Osprey population and breeding success in the western half, in keeping with Ogden's 1977 prediction. In the Loon Lake study area, the more stable water levels in the eastern half acted to some extent as a "control" (Table 1).

Exceptional multi-year productivity at four individual nests

Favourable local habitat and its selection by unusually successful Ospreys, can in rare instances overcome general trends. In the entire study area, four exceptional nest locations produced many more than their expected share of young, supporting Poole's statement (1989:132) that some Ospreys "are better parents than others." The two most successful Osprey-built nests were paradoxically in the west. Two unusually successful artificial structures were in the east. The two Osprey-built western nests, each at the top of a live spruce, accounted for 41 percent of the nestlings raised among all 51 sites in the west: at Branch Lake North

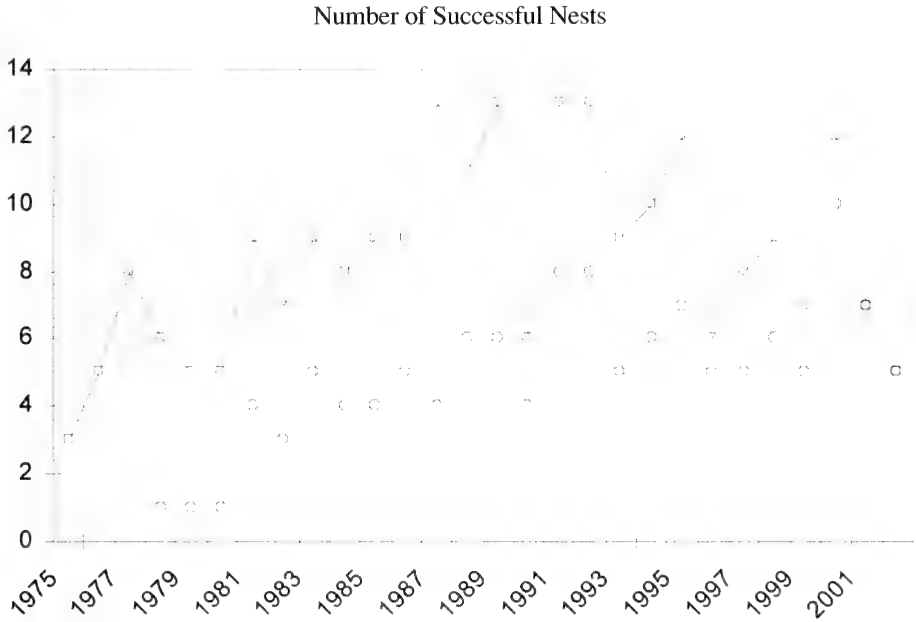


FIGURE 3. Number of nestlings banded each year, 1975-2002. West: significant decrease over the time of observation, slope = -0.278, R^2 = 0.280, P = 0.004. East: significant increase over the time of observation, slope = +0.365, R^2 = 0.3204, P = 0.003.

45 nestlings were produced in 20 successful nesting attempts through 1998 and at the southwest bay of Peck Lake 33 nestlings were raised in 17 successful attempts through 1996. The two most successful human-built structures were both in the east: the platform on the shore of Tullibee Lake, where 26 young fledged in 11 years of success until the nest was usurped in 2001 by a pair of Canada Geese, and the windmill in the marsh south of Jumbo Lake, where 21 young fledged in 9 years of success until the nest failed in 2002, coincident with smoke from massive fire on the other side of the lake.

Effects of human activity

Ospreys did not seem adversely affected by human activity at these lakes. Over the course of this study, Ospreys decreased at western lakes, which have short-term campgrounds and a large First Nation reservation, but cottages mainly at Little Fishing and Peck lakes. In the east, Osprey pairs increased at Makwa Lake, a lake used for training provincial water-skiers and the lake with densest cottage use, and at Tullibee Lake, where two families reside. From 1998 until the 2002 fire, most Osprey pairs were concentrated in the mixed forest, mostly jack-pine and spruce, around Tullibee Lake and extending >1 km inland from the northern edge of Makwa Lake.

The Mudie Lake Fire, 2002

The last year of this study, 2002, was noteworthy. A major forest fire, up to 10 km wide, began at Mudie Lake, burning the nests, platforms and trees throughout the main Osprey nesting area when it reached the north end of Makwa Lake (Figure 1). Young Ospreys in nests up to 5 km distant from the fire also perished.

Changing Patterns Since Study

Since 2002, additional striking changes have occurred to Ospreys in Saskatchewan. There has been a recent southward range extension through Osprey occupancy of power poles over open grassland along the east side of Murray Lake near North Battleford, and of scattered poles and platforms in Aspen Parkland along the North Saskatchewan River (Houston and Scott 2001). At Murray Lake the Ospreys have experienced a new problem: having moved south out of the forest to nest on power poles above large hayfields, the parents bring large quantities of ornamental, colourful baler twine which entangle the legs, wings and necks of nestlings; even one adult died from baler twine around its neck (Houston and Scott 2006).

During our study, Bald Eagles (*Haliaeetus leucocephalus*), a known Osprey competitor, have moved 50 to 100 km farther south. At Loon Lake, Bald Eagle populations increased from 0 pairs in 1975 to 1 pair in 1988, 2 pairs in 1990 and 5 pairs in 2010, the year that eagles occupied three nests built and occupied by Ospreys in previous years. Canada Geese (*Branta canadensis*) have usurped Osprey platforms, but only once did a Canada Goose pair take over an Osprey-built nest.

Comparison of Osprey productivity with other areas

Osprey mean clutch size seems independent of food supply (Poole 1989: 120-121, 219). The mean brood size near fledging, and the number of young produced per successful nest and per occupied nest (Table 2) are similar to similar data from a long-term study in Michigan (Postupalsky 1989).

Acknowledgments

We thank innumerable tree climbers and platform builders, but especially Marc Bechard, Martin Gerard, David G. Miller, Marten Stoffel, Kelwin Wylie and Dan Zazelenchuk. We are indebted to Marvin Brose for his assistance in locating unused windmills for our use. Alan F. Poole and Marc Bechard provided constructive comment of an earlier version of this paper, Donald S. Houston calculated the regressions, and Sergej Postupalsky, A. J. Erskine, Gary Bortolotti, Joseph K. Schmutz, and two anonymous reviewers must be credited with many recent improvements.

Documents Cited (marked * in text)

Anonymous. 1962. 1973. Ministikwan Lake Commercial Production Report.

Harrison, T. 1983. Water levels at Ministikwan Lake.

Dunn, C. R. 1985. Sport Fish Management Study, Saskatchewan Fisheries Branch. 1985a. Little Fishing Lake, 25 June 1985; 1985b. Peck Lake, 27 June 1985.

Durbin, J. K. 1981-1983. Recreational Fish Management Study, Saskatchewan Fisheries Branch. 1981a. Little Fishing Lake, 20-21 June 1981; 1983a. Murphy Lake, 8-9 June 1983.

Snell, D. E. 1973-1979. Sport Fish Management Study, Saskatchewan Fisheries Branch. 1973a, 1978a. Big Jumbo Lake, 17-18 September 1973, 28-30 August 1978; 1974a, 1978b. Galletly Lake, 1 March 1974, 1 June 1978; 1973b, 1979a. Ministikwan Lake, 28-30 August 1973, 29 August 1979; 1979b. Peck Lake, 28 August 1979.

Twanow, J. M. 1986-1995. Sport Fish Management Study, Saskatchewan Fisheries Branch: Big and Little Jumbo Lakes, 13 July 1988, 14 June 1994; Branch Lake, 7 June 1989, 23 June 1994; Fowler Lake, 8 June 1989, 17 June 1994; 1986a. Galletly Lake, 1 August 1986, 10 June 1987; 1994a. 21 June 1994; 1994a. Little Fishing Lake, 19 June 1990, 22 June 1994; Makwa Lakes, 14 July 1988, 6 June 1989, 25-26 May 1994; 1988a. Ministikwan Lake History, 1988; Ministikwan Lake, 26 June 1990, 27 June 1995; Murphy Lake, 9 June 1989, 16 June 1994; 1993a. Peck Lake, 31 July 1986, 13 July 1989, 29 June 1993; Tullibee Lake, 3 September 1986, 9 June 1994; 1987a. Worthington Lake, 11 June 1987.

Wallin, L. A. 1974-83. Sport Fish Management Study, Saskatchewan Fisheries Branch: Little Jumbo Lake, 26-27 July 1983; Makwa Lake, 28-29 July 1983; Peck Lake, 19-20 June 1974; Tullibee Lake, August 27-28, 1979; Worthington Lake, 25-26 June 1975, 30-31 May 1978, 30-31 May 1983. 1990a. Winter Limnology Report 13 March 1990.

Literature Cited

Bowman, R., G. V. N. Powell, J. A. Hovis, N. C. Kline, and **T. Wilmers.** 1989. Variations in reproductive success between subpopulations of the Osprey (*Pandion haliaetus*) in South Florida. Bulletin of Marine Science 44:245-250.

Houston, C. S., and **F. Scott.** 1992. The effect of man-made platforms on Osprey reproduction at Loon Lake, Saskatchewan. Journal of Raptor Research 26: 152-158.

Houston, C. S., and **F. Scott.** 2001. Power poles assist range expansion of Ospreys in Saskatchewan. Blue Jay 59: 182-187.

Houston, C. S., and **F. Scott**. 2006. Entanglement threatens Ospreys at Saskatchewan nests. Journal of Raptor Research 40: 226-228.

Houston, C. S., and **F. Scott.** 2007. An Osprey banding program near Loon Lake, Saskatchewan, 1975–2002. Blue Jay 65: 133-137.

Ogden, J. C. 1977. A preliminary report of a study of Florida Bay Ospreys. Pages 143-152 *in* Transactions of the North American Osprey Research Conference. *Edited by* J.C. Ogden. U.S. National Park Service, Washington, D.C.

Poole, A. 1982. Brood reduction in temperate and sub-tropical Ospreys. Oecologia 53: 111-119.

Poole, A. F. 1989. Ospreys: A Natural and Unnatural History. Cambridge University Press, Cambridge, U.K.

Postupalsky, S. 1974. Raptor reproductive success: some problems with methods, criteria, and terminology. Pages 21-31 *in:* Management of Raptors. Raptor Research Report Number. 2. *Edited by* F. N. Hamerstrom, Jr., B. E. Harrell, and R. R. Oldendorff.

Postupalsky, S. 1989. Osprey. Pages 297-313 *in* Lifetime Reproduction in Birds. *Edited by* I. Newton. Academic Press, London, England.

Scott, F., and **C. S. Houston.** 1985. Success of Osprey nest platforms near Loon Lake, Saskatchewan. Blue Jay 43: 238-242.

Steenhof, K., and **I. Newton.** 2007. Assessing raptor nest success and productivity. Pages 181-191 *in* Raptor Management and Research Techniques. *Edited by* D. M. Bird and K. L. Bildstein. Hancock House, Surrey, British Columbia.

Received 20 May 2010
Accepted 12 August 2010

Mineral Lick Visitation by Mountain Goats, *Oreamnos americanus*

CLIFFORD G. RICE

Wildlife Program, Washington Department of Fish and Wildlife, 600 Capitol Way N., Olympia, Washington 98501 USA; e-mail: ricecgr@dfw.wa.gov.

Rice, Clifford G. 2010. Mineral lick visitation by Mountain Goats, *Oreamnos americanus*. Canadian Field-Naturalist 124(3): 225–237.

Many species, including Mountain Goats (*Oreamnos americanus*), are known to visit mineral licks, but the extent and duration of use are poorly understood because most studies consist of observations at licks. I studied the movements to, from, and near mineral licks of 11 mountain goats in Washington wearing Global Positioning System (GPS) collars for a total of 169 goat-months of tracking and evaluated chemical composition of six mineral licks compared with reference soil samples. I recorded 101 mineral lick visits to 13 mineral licks. Each GPS fix was classified as moving toward a mineral lick, in the vicinity of a lick, on an excursion from a lick, moving away from a lick, or not associated with lick use. Depending on annual movement patterns associated with lick use, each Mountain Goat was classified as a Migrant (single lick visit of long duration, $n = 3$ Mountain Goats), Sojourner (few visits of short duration, $n = 2$), Commuter (many visits of short duration, $n = 5$), or Resident (lick within normal range of movements, $n = 1$). Most mineral lick visits took place 01 June–15 August with peak visitation about 14 June–29 July. Migrants typically stayed in the vicinity of licks about a month (but as long as 51 days) whereas other mountain goats visited licks for 0.1–8 days (median = 1 day). Migrants also tended to take longer and move farther than other Mountain Goats when on movements to and from licks. Most Mountain Goats moved toward mineral licks faster (km/hr) than they moved away from licks. All licks had higher concentrations of sodium than reference samples (1.5–27 times as high), although concentrations of calcium, potassium, and sulphate tended to be higher as well, whereas magnesium was not. Mineral lick visitation has costs (energetics of travel, reduced forage, and predation risk). Depending on the importance of these costs, mountain goats evidently use various strategies for exploiting mineral licks as exemplified by the movement types (migrant, sojourner, commuter, or resident). Notably, most of the Mountain Goats in this study crossed national forest, county and Washington Department of Fish and Wildlife region boundaries to another to visit mineral licks. Thus, coordination among administrative units is needed in management of Mountain Goats and mineral licks they use.

Key Words: Mountain Goats, *Oreamnos americanus*, Global Positioning System (GPS), mineral lick, movements, Washington.

The use of mineral licks has been documented for numerous species (Klaus and Schmid 1998), especially ungulates (Jones and Hanson 1985; Kreulen 1985; and many others) including mountain goats (*Oreamnos americanus*, e.g., Hebert and Cowan 1971; Singer and Doherty 1985; Poole and Heard 2003; Turney and Blume 2004; Poole et al. 2010). Most studies have emphasized chemical composition of lick soils (e.g., Kennedy et al. 1995; Tracy and McNaughton 1995, Dormaar and Walker 1996; Ayotte et al. 2006) or monitored visitation to licks (e.g., Tankersley 1984; Moe 1993; Atwood and Weeks 2002; Turney and Blume 2004) and provide at most, anecdotal accounts of movements to and from mineral licks (Heimer 1974; Tankersley 1984; Hnilicka et al. 2002). One exception to this is the study of movements of White-tailed Deer (*Odocoileus virginianus*) visiting licks in Indiana (Wiles and Weeks 1986).

Although there has been considerable discussion of the potential benefit from mineral licks (Kreulen 1985; Klaus and Schmid 1998), for ungulates in seasonal environments, the preponderance of evidence points to sodium as the constituent primarily associated with licks (Kennedy et al. 1995; Klaus and Schmid 1998; Atwood and Weeks 2002). Sodium concentrations in lick soils were consistently much higher than in reference soil samples and were deficient in forage (Klein and Thing 1989; Ayotte et al. 2006; Mincher et al. 2008). Also, during the time of greatest lick use (late spring and early summer), sodium requirements are high as this corresponds to late gestation and early lactation for many species and elevated potassium in forage plants at that time increases the need for sodium (Weeks and Kirkpatrick 1976; Atwood and Weeks 2002). Foley et al. (1995) indicated that sodium may be important in mediating the acidification resulting from detoxification of forage secondary compounds. Others have suggested that magnesium is a key component of lick soils (Jones and Hanson 1985; Heimer 1988; Klaus and Schmid 1998).

Despite these evident benefits, visiting mineral licks incurs costs. These are in the form of energetic costs of movement, potentially increased risk of predation in unfamiliar terrain and suboptimal habitat lacking escape terrain, and loss of foraging opportunity due to time budget constraints and potentially reduced forage availability due to poor habitat or high levels of use in the vicinity of the lick. Because the costs and benefits vary among licks and among individuals, patterns of mineral lick use can be expected to vary depending on the quality of the lick, distance to the lick, terrain that must be traversed to visit the lick,

mineral content of the soils and vegetation in the "normal" home range of the individual, and habitat in the vicinity of the lick.

Prior to this study, knowledge of mineral lick use by Mountain Goats in Washington was limited. Wright (1977) reported Mountain Goats using a mineral lick on the flanks of Mt. Baker (exact location not specified). Representatives of the Sauk-Suiattle Tribe determined that the early summer aggregation of mountain goats on Gamma Ridge (Glacier Peak) was associated with the use of a mineral lick (D. Graupman personal communication 2001). To increase our understanding of the use of mineral licks by Mountain Goats in Washington, the objectives in this study were to identify mineral licks used by Mountain Goats, and to describe movements of GPS collared Mountain Goats visiting mineral licks. Because there are few comparable studies of mineral lick visitation by Mountain Goats, I described the frequency with which individuals visit mineral licks, the distances they travel in doing so, to further our understanding of how they balance the trade-offs between costs and benefits of mineral lick use. I also evaluated the chemical constituents of mineral licks mountain goats used.

Materials and Methods

Study Area

I studied Mountain Goat mineral licks in the Cascade Range in Washington State where topography extends as high as 4267 m on several volcanic peaks, but most terrain is below 2100 m. In this area, Mountain Goats typically inhabit elevations between 600 and 2400 m, which have six broad classes of vegetative cover (derived from Comer et al. 2003): Bare (1510–4270 m), which includes bedrock, scree, talus, and dwarf shrubs; Grassland (1170–2190 m); Parkland (1180–2080 m); Woodland (600–1840 m); Forest (600– 1470 m); and Shrubland (600–1380 m).

Capture and Collaring

I captured 46 Mountain Goats in the Cascade Mountain Range between 26 September 2002 and 2 July 2007 (Rice and Hall 2007) and fitted them with GPS tracking collars (Vectronic GPS Plus-4, Vectronics Aerospace, Berlin, Germany). All captures were in compliance with Washington Department of Fish and Wildlife Policy on Wildlife Restraint or Immobilization (M6003). The primary purpose of these captures was to provide locations for studies of movements and habitat selection (Wells 2006) and to provide marked groups for sightability modeling for surveys (Rice et al. 2009). Only the 11 collared mountain goats known to visit mineral licks are included in this study (Table 1). Seven of these were captured near the licks on Gamma Ridge (Glacier Peak) in 2006 to improve our understanding of movements of Mountain Goats associated with mineral licks and Gamma Ridge in particular. One capture took place in the vicinity of the Deadhorse Point lick. Because our overall study emphasized females, only 1 of the 11 mountain goats that visited mineral licks was an adult male (038GMM) and the extent to which his mineral lick use reflected his sex (Hebert and Cowan 1971; Ayotte et al. 2008; Poole et al. 2010) or that he had a mineral lick within his normal range is an open question. 051GPM was also a male, but was captured at 1 year of age, and, in terms of lick visitation, probably behaved more like the adult females during the 13 months he was tracked.

Most Mountain Goats in this study captured prior to 2006 (033GPF, 034GPF, 037HRF, 045MRF, and 038GMM) were set on a 3 hr fix interval. The exception was 024KRF which was on a 5 hr rotating schedule from 13 September 2003 to 28 June 2004, and subsequently on a 3 hr interval. The collars for the 2006 captures (051GPM, 052GPF, 053GPF, 054GPF, and 055GPF) were on a 5 hr rotating schedule most of the year but on a 1 hr interval 07–21 June and 25 July–20 August, when movements to and from Gamma Ridge were expected. I removed outlier fixes by visually screening locations beyond the continuous distribution of distances of all fixes from the median for each individual and by visual inspection of travel paths (usually single fixes separate from temporal clusters, Rice 2008). The median estimated location error (Lewis et al. 2007) for fixes used to determine movements to mineral licks and habitat was 9.6 m (central 95% = 5.9–129.8, $n = 9165$).

Identifying Licks

Mineral licks used by collared Mountain Goats were identified in three ways: on the basis of previous knowledge; field observations; and in two cases, movement records from GPS collars which were to clusters of fixes 4-5 km outside the range of movements for that individual. Other mineral licks probably occurred within areas of movement for some collared mountain goats. Such licks might or might not be associated with clusters of collar fixes as this was variable for known licks. Within the usual movements for an individual, it was not feasible to distinguish clusters of fixes associated with licks from those associated with other locations of high use (e.g., favored resting sites) without independent information on the location of the lick. Field observations were made on mineral lick use on Gamma Ridge on 25 and 26 July 2007, during which six new mineral lick sites were identified by observing mountain goat use.

Movements

I identified five states for mountain goats determined by movements relative to mineral licks: (1) At Lick, (2) moving Toward the lick, (3) moving Away from the lick, (4) on an Excursion from the lick, and (5) None (none of the above), collectively termed Lick State. A Mountain Goat was considered At Lick if the fix was within the vicinity and within a specified distance from the lick (same as region 2 of Hebert and Cowan 1971). This distance varied among the Mountain Goats and was determined by examining time series graphs of distance from the lick and between-

TABLE 1. Mountain Goats visiting mineral licks tracked with GPS collars in Washington. Sex is indicated by the last letter of the individual designation (F = female, M = male). Age is at time of capture. Max distance is the maximum distance from the nearest mineral lick when At Lick (m).

Type	Goat	Age	Area	Dates		Fixes	Months	Visits	Max
				Minimum	Maximum		tracked		distance
Migrant	033GPF	4	Gamma Ridge	9 July 2004	6 June 2005	2036	11	1	1400
	034GPF	4	Gamma Ridge	9 July 2004	22 September 2006	3200	26	5	1400
	051GPM	1	Gamma Ridge	29 June 2006	25 July 2007	2025	13	2	2475
Sojourner	024KRF	3	French Cabin Creek	13 September 2003	14 November 2005	4711	26	5	400
	037HRF	3	Deadhorse Point	10 July 2004	10 February 2006	3055	19	7	1275
Commuter	045MRF	5	Mineral Mountain	3 September 2004	10 August 2005	1841	11	11	850
	052GPF	6	Gamma Ridge	29 June 2006	5 September 2006	780	2	4	700
	053GPF	5	Gamma Ridge	29 June 2006	30 May 2007	1549	11	3	1150
	054GPF	4	Gamma Ridge	29 June 2006	19 September 2007	3067	15	13	1050
	055GPF	2	Gamma Ridge	30 June 2006	14 March 2007	1319	8	5	850
Resident	038GMM	3	Gardner Mountain	10 July 2004	9 September 2006	5022	26	45	625
	All			13 September 2003	19 September 2007	28605	169	101	

fix paths for each lick area. Generally, starting and ending fixes of movements Toward and Away were clearly evident in time series graphs of distance from the lick, but when questions arose, I used the rule that the movements were considered continuous if the distances for the fixes in question covered a period of < 2 days. Excursions were movements Away immediately followed by movements Toward which did not reach the typical distances of Toward and Away for that individual.

Based on the Lick States, I calculated the Duration of each State, and the change in Distance to the lick (in km) between the first and last fixes in each State. I defined the Interval between mineral lick visits as the difference (in days) between the start of movement Toward and the end of the previous movement Away for each visit and partitioned these Intervals into those that were within a given year and those between years (over winter).

Based on movement records, I classified each individual as one of four Types: Migrant, Commuter, Sojourner, or Resident. Migrants moved to the lick and stayed for an extended period (>2 weeks). Commuters moved to and from the lick frequently within a season. Sojourners visited the licks briefly, and if they visited a lick more than once in a season, visits were separated by >2 weeks. The Resident visited a lick located within his normal range of movements.

Analysis

To test for differences in measures of mineral lick use among visitor Types and Lick States, I included individual identity as a random effect because multiple visits are repeated measures on the same individual and used the Tukey test for multiple comparisons of the means of the different groups (Zar 1996). To address distribution considerations (skewness of pooled samples = 0.813–4.121), I log-transformed Durations, Intervals, Distances and movement rates. For movement rate analysis, I adjusted for the fact that collars were programmed with varying fix intervals and that not all fix attempts were successful by including realized fix interval (in hours) as a categorical nuisance variable. Statistical analysis was conducted with JMP (v7.0, SAS Institute 2007).

Lick Sampling and Analysis

Soil samples were collected at two mineral licks on Gardner Mountain and five licks on Gamma Ridge (Figure 1). At each site, reference samples were collected 50 m upslope, downslope, and to each side of the site. Each sample was analyzed for chemical constituents frequently referenced in the earlier reports (e.g., Kennedy et al. 1995; Ayotte et al. 2006): Sodium (Na), Calcium (Ca), Potassium (K), Magnesium (Mg), and sulphate (SO_4) which were assayed by Kuo Soil Labs (Othello, Washington). Because the distributions of chemical concentrations were skewed, I log-transformed all values. Te evaluate if chemical concentrations differed between lick and reverence samples, I

used a nested ANOVA design (lick vs reference within site). I also checked that reference samples from the downslope of the site did not differ from other reference samples with a 1- sided t-test, in case drainage from the lick site may have elevated concentrations for the downslope sample.

Results

Movements

Of the eight Mountain Goats captured near mineral licks, three were Migrants, one was a Sojourner, and four were Commuters. The Migrants stayed in the vicinity of the lick a median of 38.6 (range 23.9-38.7) days after capture. The Sojourner stayed 5.9 after capture, and the Commuters stayed in the vicinity a median of 2.8 (range 2.6-3.5) days after capture. It would appear that capture did not have much effect on lick visitation (see below).

Mountain Goats generally followed mountain ridges when moving Toward and Away from mineral licks (Figure 2). However, this was only partially true for Migrants, which followed ridges initially when moving toward the licks, but then crossed the Suiattle River valley rather than detour along the ridge to the south (paths in the upper half of box for Gamma Ridge, Figure 2). Also, 045MRF crossed the lower part of the Winthrop Glacier on her many trips Toward and Away.

Movements Toward and Away from mineral licks by Mountain Goats were usually decisive (Figure 3), but there were exceptions. For instance, in 2006, 034GPF stopped her movement 6 km from the Gamma Ridge mineral licks, retreated to 11 km from the licks for four days, resumed her movement toward the lick, but paused again at 6 km for 2.5 days before moving to the licks (Figure 3). In 2005, 034GPF turned and ascended along the Suiattle River 4 km over two days before continuing to the licks. Although the mineral licks for the Resident (038GMM) was enclosed by other areas he visited, the radial nature of his Toward and Away moments suggests that the lick was the main reason he visited the area of the lick (Figure 2).

Most (90%) mineral lick visits took place 1 June–15 August but this varied among Types. Apart from a few early visits to mineral licks, Migrants, Sojourners, and Commuters, all started lick visits in mid-June (14 June, 14 June, and 17 June, respectively, Figure 4). The Resident started regular lick visits on 29 April, and activity increased on 25 May (Figure 4). All Types ceased regular visits near the end of August (Migrants-24 August, Sojourners-19 August, Commuters-26 August, and Resident 21 August) although there were gaps in visitation for Sojourners (13 July–02 August), Commuters (09–17 August), and the Resident (26 July–11 August). Altogether, peak visitation was about 14 June–29 July. Early and late visits to mineral licks also occurred, especially for the Resident, but also for other Types except Migrants (Figure 4). Typical number of days At Lick in a year was highest for Migrants (44), intermediate for the Resident and Commuters (28 and 21), and lowest for Sojourners (13).

Migrants typically stayed At Lick >1 month per visit (Table 2), which was significantly longer than other Types (Table 2, $F_{3,6} = 10.251$, $P = 0.009$). Sojourners were usually At Lick 2–3 days and not more than about one week whereas Commuters usually stayed at lick about one day or one week at the most. The Resident's visits were shorter (Table 2), although differences among Sojourners, Commuters and Resident were not significant. The Duration of movements Toward were less than Away (Table 2, $F_{1,124} = 9.793$, $P = 0.002$, Table 2).

Within a given year, Commuters and the Resident had similar Interval between mineral lick visits, which was much shorter than those for Sojourners ($F_{2,49} = 5.816$, $P = 0.005$, Table 3). Between year Interval observations were too sparse for meaningful testing (Table 3).

The longest Distance a Mountain Goat moved Toward or Away from a mineral lick was 29.4 km and the shortest Distance was 0.6 km (Table 4). Typical movements for Migrants were >15 km, whereas those for Sojourners and Commuters were more variable (4–17 km), with the Resident's movements usually much shorter although these differences were marginally not significant (Away $F_{3,6} = 4.526$, $P = 0.059$; Toward ($F_{3,5} = 5.409$, $P = 0.050$). Generally, Distance moved was slightly greater Toward than Away ($F_{1,122} = 6.245$, $P = 0.014$).), movement rate (m/hr) was highest during Toward, nearly three times the rate when in lick state None and Away was also higher than lick state None (Table 5, $F_{4,\ 8395} = 101.941$, $P < 0.001$). This demonstrates the energetic costs of mineral lick movements. Movement rates did not vary significantly among Types ($F_{3,\ 7} = 0.492$, $P = 0.699$).

Soil Samples

Sodium concentrations were significantly higher in lick soils than in reference soils at all licks and were >20 times higher for two licks (GAM1 and GAM3, Table 6). Other chemicals had significantly higher concentrations at some licks (K at 3 licks, Mg at 1, and SO_4 at 1). Despite the lack of consistently significant differences, concentrations of Ca, K, Mg, and SO_4 were generally higher at licks than in reference samples. Downslope samples were not significantly higher than the other reference samples at each site for any chemicals with regards to either concentration of difference from the site sample ($t_{1-2} = 0.016$–0.984, 3 of 70 tests were with $P < 0.05$).

Discussion

We tracked 46 Mountain Goats distributed over a wide geographic range in Washington (Rice and Hall 2007; Rice 2008), but only 11 exhibited pronounced movements associated with mineral licks and eight of these were captured while visiting known licks. The results show that there is wide variation in the details of mineral lick visitation among individuals in terms

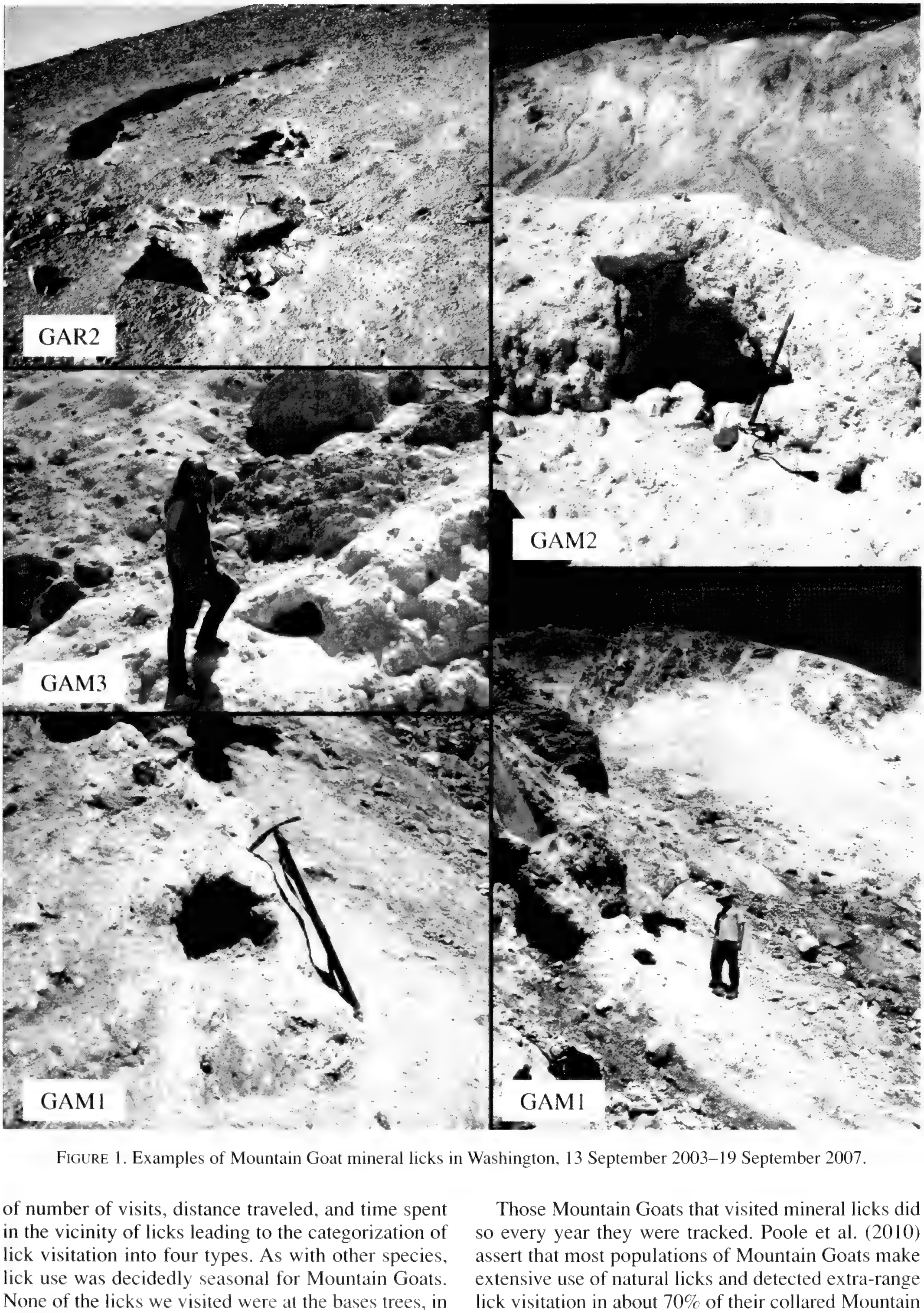


FIGURE 1. Examples of Mountain Goat mineral licks in Washington, 13 September 2003–19 September 2007.

of number of visits, distance traveled, and time spent in the vicinity of licks leading to the categorization of lick visitation into four types. As with other species, lick use was decidedly seasonal for Mountain Goats. None of the licks we visited were at the bases trees, in contrast to those investigated by Poole et al. (2010) in southeastern British Columbia.

Those Mountain Goats that visited mineral licks did so every year they were tracked. Poole et al. (2010) assert that most populations of Mountain Goats make extensive use of natural licks and detected extra-range lick visitation in about 70% of their collared Mountain Goats in two populations. They also noted the difficulty in documenting lick use from GPS collar records

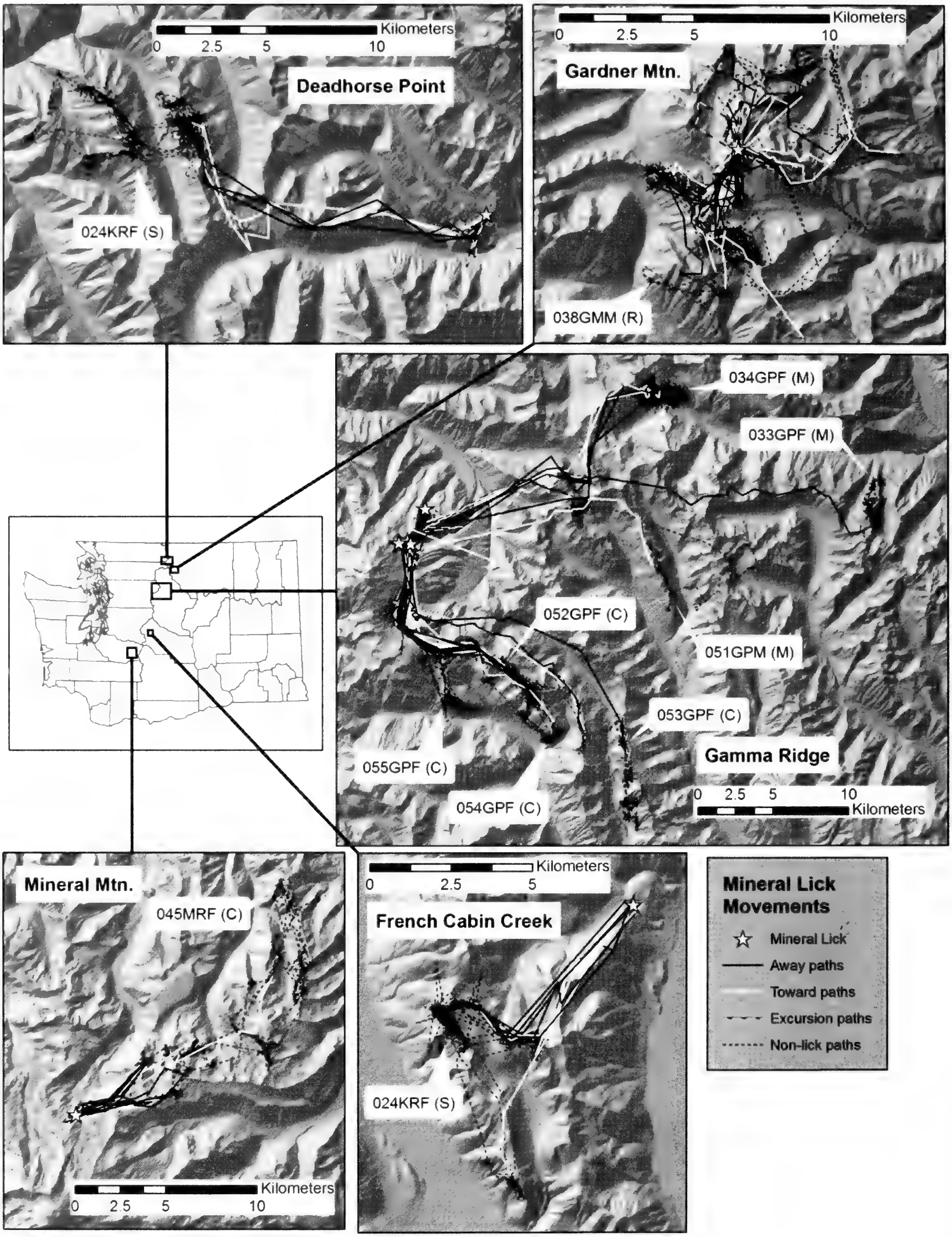


FIGURE 2. Movements of GPS-collared mountain goats toward and away from mineral licks in Washington, 13 September 2003–19 September 2007. Non-lick paths for each Mountain Goat are indicated by callout boxes giving the goat name and Type in parenthesis (M = Migrant, S = Sojourner, C = Commuter, and R = Resident).

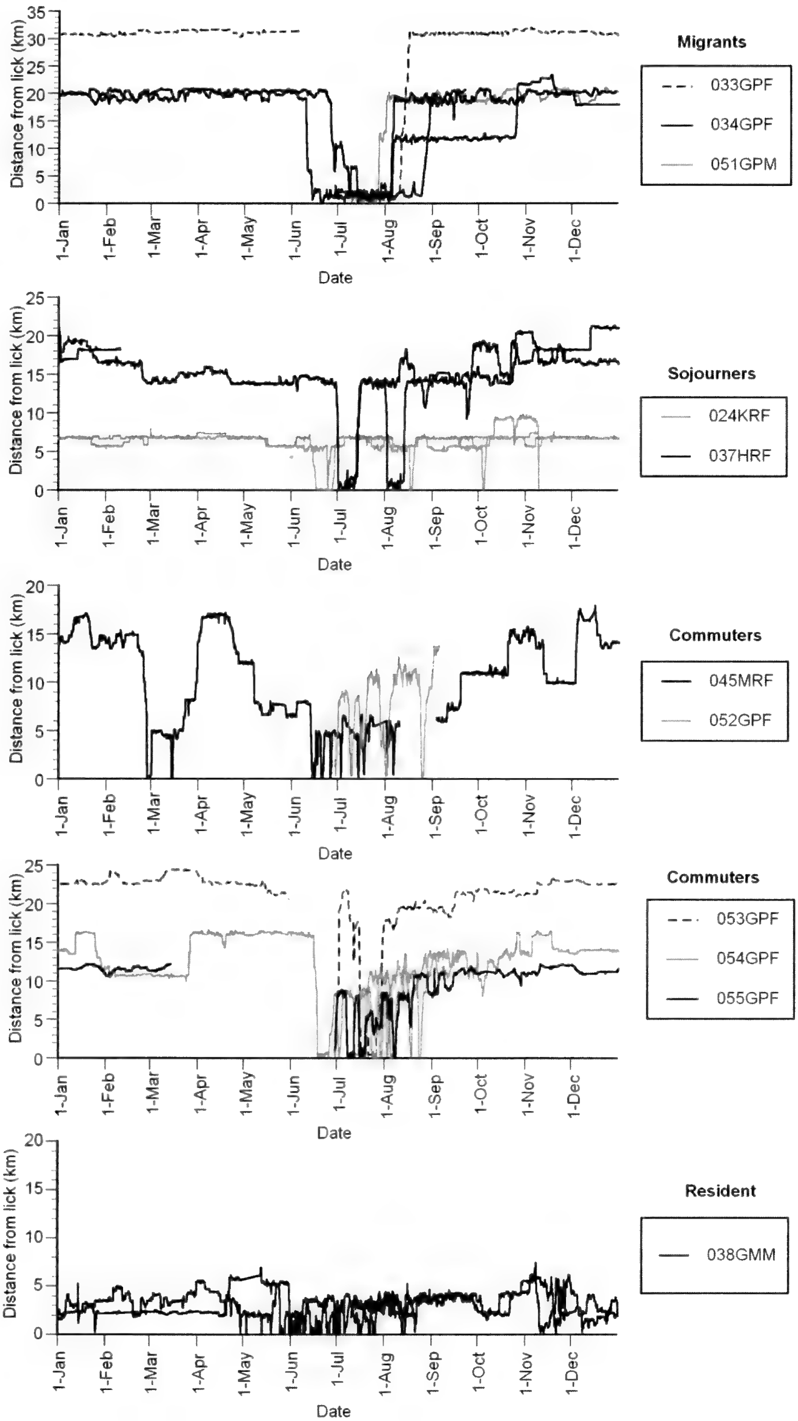


FIGURE 3. Distance from their respective mineral licks for 11 Mountain Goats in Washington, 13 September 2003–19 September 2007. Multiple lines for an individual indicate multiple years of tracking.

TABLE 2. Median, maximum, and minimum Duration of Lick States (moving Toward lick, At Lick, Excursion from lick, and moving Away from lick) in days for individual Mountain Goats in Washington, 13 September 2003–19 September 2007.

Type	Goat	Toward				At Lick				Excursion				Away			
		Median	Min	Max	n	Median[1]	Min	Max	n	Median	Min	Max	n	Median	Min	Max	n
Migrant	033GPF	.	.	.	0	31.8	31.8	31.8	1	.	.	.	0	6.3	6.3	6.3	1
	034GPF	9.2	4.1	14.3	2	18.3	0.5	51.5	5	3.8	5.1	2.5	2	5.1	2.4	7.0	3
	051GPM	2.2	2.2	2.2	1	35.0	33.0	37.1	2	.	.	.	0	1.0	1.0	1.0	1
	All	4.1	2.2	14.3	3	32.4[a]	0.5	51.5	8	3.8	5.1	2.5	2	5.1	1.0	7.0	5
Sojourner	024KRF	1.0	0.3	4.0	5	1.5	0.1	7.9	5	.	.	.	0	2.1	1.5	2.8	5
	037HRF	1.7	1.6	1.8	2	2.4	2.0	5.4	7	0.5	3.0	0.3	4	3.1	1.9	3.6	3
	All	1.6	0.3	4.0	7	2.4[b]	0.1	7.9	12	0.5	3.0	0.3	4	2.1	1.5	3.6	8
Commuter	045MRF	0.3	0.1	2.4	10	0.4	0.1	2.0	11	0.8	0.8	0.8	1	1.0	0.3	1.6	10
	052GPF	1.5	1.3	4.1	3	1.1	0.4	1.7	4	.	.	.	0	3.1	1.7	6.3	4
	053GPF	1.0	1.0	1.0	1	2.5	0.2	7.5	3	2.3	2.3	2.3	1	3.7	2.5	4.9	2
	054GPF	0.9	0.4	2.3	11	1.5	0.6	7.6	13	0.2	0.2	0.2	1	1.7	0.5	4.6	12
	055GPF	1.1	0.8	1.5	3	1.6	1.3	4.0	4	1.7	1.7	1.7	1	1.5	1.3	2.0	3
	All	1.0	0.1	4.1	28	1.3[b]	0.1	7.6	35	1.2	2.3	0.2	4	1.5	0.3	6.3	31
Resident	038GMM	0.5	0.1	3.0	26	0.8[b]	0.1	2.9	45	0.5	2.3	0.1	19	1.0	0.1	4.9	26
All	All	1.0	0.1	14.3	64	1.0	0.1	51.5	100	0.5	5.1	0.1	29	1.5	0.1	7.0	70

[1]letters indicate statistically significant differences between Types.

within a Mountain Goat's normal range of movements. Thus, just how many of the 35 mountain goats we tracked for which we could not document mineral lick use did not use licks and how many used licks we did not detect remains an open question, but my subjective assessment is that a number of them did not use licks. Notably, Festa-Bianchet and Côté (2008) did not report any natural mineral lick use over 15 years of study of the Caw Ridge (Alberta) Mountain Goat population and Fox et al. (1989) indicated that lick use was not evident in Mountain Goats in southeast Alaska. It may be that the generally high rates of use of mineral licks by Mountain Goat populations is a consequence of the availability of licks in mountainous terrain and the lack of lick use is due to the lack of availability.

The seasonal nature of mineral lick use has been reported in other species (e.g. Weeks and Kirkpatrick 1976; Tankersley 1984; Atwood and Weeks 2002) and Mountain Goats (Hebert and Cowan 1971; Turney and Blume 2004). For mountain ungulates, the period of greatest visitation was similar to those of this study (Heimer 1974; Tankersley 1984; Turney and Blume 2004; Poole et al. 2010). The earlier onset and decline in mineral lick visitation by the Resident in this study may be due to the fact that he was a resident, that he was the only adult male in my study, or to particular characteristics of the licks and associated terrain. Notably, other reports have documented earlier lick use for males: for Mountain Goats (Hebert and Cowan 1971; Poole et al. 2010; J. Mainguy, personal communication, 2008); Moose (*Alces alces*), Fraser and Hristienko 1981; Tankersley and Gasaway 1983; and Dall Sheep (*Ovis dalli dalli*), Tankersley 1984. In mountain environments, snow may impede and hence delay long-distance movements compared to lower elevations and may explain the later peak in mineral lick visitation by Migrant Mountain Goats.

Although I did not find significant differences among Types for Durations of States other than At Lick, it seems likely that this was due to low statistical power (given the small sample sizes) rather than the lack of actual differences. For States of Toward and Away, Sojourners had Durations approximately half those of Migrants, Commuters had Durations approximately half those of Sojourners, and the Resident had Durations approximately half those of Commuters (Table 2). A similar progression was evident in the non-significant Distances, except that Sojourner and Commuter Distances were approximately equal (Table 4).

Mineral lick use can be considered in a cost-benefit framework, in which the benefit is the chemical constituents available from the lick (Kreulen 1985; Klaus and Schmid 1998) and the costs are the energetic costs of traveling Toward and Away, reduction of foraging opportunity, and increased predation risk associated with travel and remaining in the vicinity of the lick. Foraging opportunity was probably reduced in the vicinity of most licks. The Deadhorse Point and French

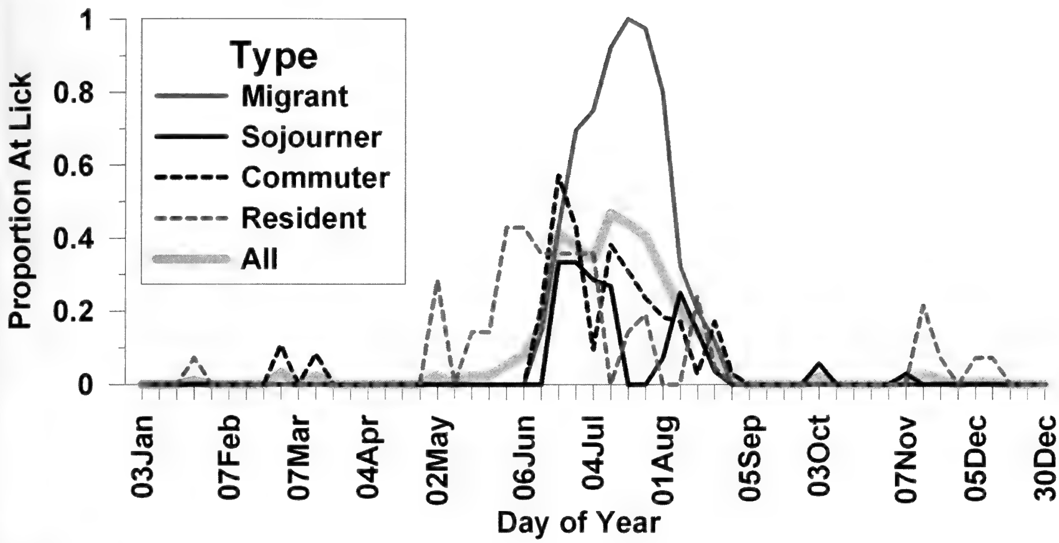


FIGURE 4. Weekly means of the daily proportion of Mountain Goats At Lick for each Type in Washington, 13 September 2003–19 September 2007.

TABLE 3. Median, minimum, and maximum Intervals (difference, in days, between the start of Toward and the end of the previous Away) between mineral lick visits by Mountain Goats taking place in the same year and between years (over winter) in Washington, 13 September 2003–19 September 2007.

		Same year				Between years			
Type	Goat	Median	Min	Max	*n*	Median	Min	Max	*n*
Migrant	033GPF	.	.	.	0	.	.	.	0
	034GPF	.	.	.	0	316.7	312.4	321.0	2
	051GPM	.	.	.	0	317.8	317.8	317.8	1
	All	.	.	.	0	317.8	312.4	321.0	3
Sojourner	024KRF	64.8	51.0	78.5	2	237.4	224.5	250.2	2
	037HRF	16.4	16.4	16.4	1	318.9	318.9	318.9	1
	All	51.0[a]	16.4	78.5	3	250.2	224.5	318.9	3
Commuter	045MRF	5.5	0.9	89.6	9	.	.	.	0
	052GPF	15.5	6.3	16.9	3	.	.	.	0
	053GPF	12.9	12.9	12.9	1	.	.	.	0
	054GPF	6.0	1.5	16.2	10	290.5	290.5	290.5	1
	055GPF	5.2	1.7	16.5	3	.	.	.	0
	All	6.3[b]	0.9	89.6	26	290.5	290.5	290.5	1
Resident	038GMM	3.1[b]	0.4	93.5	23	143.1	124.5	161.6	2
All	All	5.6	0.4	93.5	52	290.5	124.5	321.0	9

[1]letters indicate statistically significant differences between Types

Cabin Creek licks were in timbered areas which may have less forage available than open areas, although this was not the case with the subalpine licks (Gardner Mountain, Gamma Ridge, and Mineral Mountain). Also, it is highly likely that forage in the vicinity of licks is over-utilized by high concentrations of visiting Mountain Goats (Cowan and Brink 1949). For Mountain Goats, predation risk probably increases in unfamiliar terrain and with restricted visibility in forested habitats (Cowan and Brink 1949; Festa-Bianchet et al. 1994; Côté and Beaudoin 1997). As such, predation risk would be considered higher for visits to Deadhorse Point and French Cabin Creek licks, but less for the subalpine licks. Also, Gamma Ridge differed from the other lick areas in that extensive alpine meadows and escape terrain occurred in the vicinity of the licks. However, Migrants visiting the Gamma Ridge licks traveled though timbered terrain on route to the subalpine licks there. The artificially high concentrations of Mountain Goats in the vicinity of licks may also increase predation risk. The tradeoffs in these factors have apparently resulted in the lick visit Types, where the Mountain

TABLE 4. Median, maximum, and minimum Distance (km) and movement rate (km/hr) for individual mountain goats moving Toward and Away from a mineral lick from the first fix of the movement to the last in Washington, 13 September 2003–19 September 2007.

		Distance						Movement Rate						n	
		Toward			Away			Toward			Away				
Type	Goat	Median	Min	Max	Median	Min	Max	Median	Min	Max	Median	Min	Max	Toward	Away
Migrant	033GPF	.	.	.	29.4	29.4	29.4	.	.	.	0.20	0.20	0.20	0	1
	034GPF	18.0	17.6	18.3	17.9	15.9	18.2	0.12	0.05	0.18	0.13	0.11	0.31	2	3
	051GPM	15.6	15.6	15.6	7.9	7.9	7.9	0.29	0.29	0.29	0.32	0.32	0.32	1	1
	All	17.6	15.6	18.3	17.9	7.9	29.4	0.18	0.05	0.29	0.20	0.11	0.32	3	5
Sojourner	024KRF	5.5	5.5	8.9	6.4	5.3	6.7	0.22	0.06	0.92	0.13	0.10	0.16	5	5
	037HRF	13.7	13.4	14.0	12.5	12.1	12.9	0.34	0.33	0.34	0.16	0.15	0.28	2	3
	All	5.6	5.5	14.0	6.7	5.3	12.9	0.33	0.06	0.92	0.14	0.10	0.28	7	8
Commuter	045MRF	4.6	4.1	12.8	4.7	4.2	6.5	0.61	0.22	1.45	0.19	0.13	0.73	10	10
	052GPF	10.1	8.1	10.3	8.7	7.7	12.1	0.23	0.10	0.34	0.12	0.08	0.20	3	4
	053GPF	16.8	16.8	16.8	17.1	16.1	18.2	0.67	0.67	0.67	0.22	0.14	0.30	1	2
	054GPF	8.0	7.3	15.1	7.9	6.7	12.9	0.40	0.26	0.86	0.23	0.10	0.62	11	12
	055GPF	7.7	7.3	8.1	7.4	4.8	7.6	0.26	0.21	0.40	0.18	0.14	0.25	4	4
	All	7.8	4.1	16.8	7.5	4.2	18.2	0.40	0.10	1.45	0.19	0.08	0.73	29	32
Resident	038GMM	2.3	1.5	6.9	2.0	0.6	5.1	0.23	0.04	0.75	0.10	0.01	0.50	26	26
All	All	5.5	1.5	18.3	5.3	0.6	29.4	0.30	0.04	1.45	0.16	0.01	0.73	65	71

TABLE 5. Rate of movement (m/hr) by State and Type during the lick season (01Jun-15Aug) for mountain goats visiting mineral licks.

Effect	Level	Mean[1]	95%CI	*n*
State	Toward	70.9[a]	54.9–91.5	547
	Away	52.0[b]	40.6–66.5	787
	Excursion	34.1[bcd]	23.5–49.4	95
	At Lick	27.1[c]	21.5–34.3	1864
	None	23.7[d]	18.9–29.8	5131
Type	Commuter	44.1	33.5–58.1	3655
	Migrant	37.8	27.4–52.2	2097
	Resident	36.9	22.2–61.6	1179
	Sojourner	34.3	23.4–50.5	1493

[1]letters indicate statistically significant differences

Goat may: (1) visit the lick infrequently and remain in the vicinity for an extended period because the costs of travel are high and habitat in the vicinity of the lick is acceptable (Migrant); (2) visit the lick infrequently and remain in the vicinity for a short period because the costs of travel are high and habitat in the vicinity of the lick is unacceptable (Sojourner); or (3) visit the lick frequently and remain in the vicinity for a short period because the costs of travel are low (Commuter and Resident).

Given the low number of Mountain Goats and licks in this study, it is difficult to be certain whether these Types are artificial divisions along a continuum of responses or natural categories emerging from the trade-offs discussed above. However, other accounts of mineral lick visitation suggest they can be fit into these Types. Hebert and Cowan (1971) indicated Mountain Goats visited licks briefly once a year, which would be Sojourners. Singer and Doherty (1985) described frequent visits by Mountain Goats from Glacier National park (Commuters) but suspected that Mountain Goats coming from Flathead National Forest visited only once per year for < 2 weeks (Sojourners). The Bighorn Sheep (*Ovis canadensis*) studied by Hnilicka et al. (2002) made fortnightly visits to the lick throughout the summer (Commuters), whereas Dall Sheep (*Ovis dalli*) in Alaska visited the licks primarily during the transition from winter to summer range (Heimer 1974; Sojourners). Adult Moose (*Alces alces*) studied by Fraser and Hristienko (1981) were evidently Sojourners and Commuters, while young male Moose were Migrants. White-tailed Deer (*Odocoileus virginianus*) studied by Wiles and Weeks (1986) had licks within their usual ranges (Residents) or traveled frequently to nearby licks (Commuters).

Comparisons of licks soils across studies can be difficult due to inconsistent choices of which constituents to measure and differing methods of measurement (Klaus and Schmid 1998). Some of my measurements can be compared with those reported by Jones and Hanson (1985) for the geometric mean of 18 mineral licks used by Mountain Sheep and Mountain Goats: Na = 1.67; Ca = 27.85; Mg = 5.69. The significantly

TABLE 6. Mean concentrations of Calcium (Ca), Potassium (K), Magnesium (Mg), Sodium (Na), and sulphate (SO_4) in mineral lick (Site) and reference (Ref) soil samples in Washington and t–test evaluations of differences for each lick. Means are back transformed estimates from the average of log–transformed values. Effect is the difference in the averages of the log–transformed values (site – reference) and the t–test evaluates the hypothesis of site > reference. meq = milliequivalents.

Chemical	Mineral Lick	Concentration Site	Concentration Ref	Samples Site	Samples Ref	Effect	t	P
Ca (meq/100g)	GAM1	7.49	10.10	2	4	–0.300	0.706	0.757
	GAM2	6.77	5.96	3	3	0.127	–0.317	0.377
	GAM3	5.70	6.60	1	4	–0.146	0.267	0.604
	GAM5	6.80	4.83	1	4	0.343	–0.627	0.268
	GAR1	3.12	2.49	2	8	0.224	–0.579	0.284
	GAR2	4.71	2.82	2	8	0.512	–1.322	0.098
K (ppm)	GAM1	245.73	138.05	2	4	0.577	–1.927	0.032*
	GAM2	191.00	133.47	3	3	0.358	–1.271	0.107
	GAM3	317.00	127.17	1	4	0.913	–2.365	0.012*
	GAM5	90.00	75.40	1	4	0.177	–0.458	0.325
	GAR1	97.86	55.35	2	8	0.570	–2.086	0.023*
	GAR2	47.29	53.93	2	8	–0.131	0.481	0.683
Mg (meq/100g)	GAM1	4.05	5.71	2	4	–0.343	1.037	0.846
	GAM2	4.79	4.76	3	3	0.007	–0.022	0.491
	GAM3	4.60	3.54	1	4	0.261	–0.612	0.273
	GAM5	1.10	1.01	1	4	0.082	–0.193	0.424
	GAR1	0.39	0.22	2	8	0.582	–1.930	0.032*
	GAR2	0.30	0.24	2	8	0.203	–0.672	0.253
Na (meq/100g)	GAM1	2.39	0.12	2	4	3.003	–11.267	<0.001*
	GAM2	0.87	0.15	3	3	1.764	–7.020	<0.001*
	GAM3	4.75	0.17	1	4	3.305	–9.605	<0.001*
	GAM5	0.54	0.22	1	4	0.888	–2.580	0.008*
	GAR1	0.22	0.12	2	8	0.621	–2.554	0.008*
	GAR2	0.26	0.17	2	8	0.427	–1.755	0.045*
SO_4 (ppm)	GAM1	208.94	35.87	2	4	1.762	–2.205	0.018*
	GAM2	98.11	29.14	3	3	1.214	–1.611	0.059
	GAM3	143.13	27.32	1	4	1.656	–1.605	0.059
	GAM5	32.13	20.87	1	4	0.431	–0.418	0.339
	GAR1	5.13	4.71	2	8	0.085	–0.116	0.454
	GAR2	2.58	1.31	2	8	0.674	–0.923	0.182

*Significant at $\alpha = 0.05$

higher concentrations of Na at licks and higher concentrations, but less extreme differences for other chemicals are similar to the results of other studies (e.g. Weeks and Kirkpatrick 1976; Tankersley 1984; Klein and Thing 1989; Tracy and McNaughton 1995; Klaus and Schmid 1998; Mincher et al. 2008). This supports the conclusion that Na is the main reason the mountain goats in this study visited mineral licks. My results do not support the hypothesis that Mg is a chemical sought after at licks (Jones and Hanson 1985; Heimer 1988; Klaus and Schmid 1998). The preponderance of visits to mineral licks in the late spring and early summer suggests that the detoxification/acidosis function of Na (Foley et al. 1995) is not the driver for mineral lick visitation because secondary compounds are more prevalent in browse than grasses and forbs (Festa-Bianchet 1988), and Mountain Goat diet is typically mostly forbs and graminoids in the summer with the most browse consumed in the winter (Fox et al. 1989).

It is noteworthy that all seven Mountain Goats visiting Gamma Ridge (Migrants and Sojourners) crossed the crest of the Cascade Range during the movements Toward and Away from the licks (Figure 2). While doing so, they also crossed from one national forest to another, from one Department of Fish and Wildlife administrative region to another, and from one county of Washington to another. 037HRF also crossed region and county boundaries during mineral lick visits. Consequently, coordination among administrative units is a necessary part of managing these Mountain Goats and the mineral licks they use. Nevertheless, little is known about the degree to which disturbances (logging, recreation, road construction, trail development) may impact mineral lick movements and this may vary among Mountain Goat populations. Poole et al. (2010) gave anecdotal accounts of logging modifying, but not inhibiting Mountain Goat lick visitation, but at a road inhibited movements for about a year. It would seem

prudent to limit logging operations and road building along known mineral lick travel routes to avoid times of high lick visitation.

Acknowledgments

This study was a cooperative one and benefited from the contributions of the U.S. Forest Service (D. Gay, P. Reed), Western Washington University (T. Beus and A. Shirk), the Sauk-Suiattle Tribe (C. Danilson and E. Peterson), the National Park Service (J. Schaberl) and other employees of the Department of Fish and Wildlife (G. Falxa, S. Fitkin, B. Hall, R. Milner, and W. Moore). T. Beus, B. Kertson, L. Leschner, J. Mainguy, K. Poole, S. Pearson, E. Rice, K. White, and G. Wiles provided comments on the manuscript. Support for this work was from U.S. Fish and Wildlife Service under the State Wildlife Grants Program and Federal Aid in Wildlife Restoration, the Wildlife Research Program of Seattle City Light, the Sauk-Suiattle Tribe, and the United States Forest Service Challenge Cost Share program.

Literature Cited

Atwood, T. C., and **H. P. Weeks, Jr.** 2002. Sex- and age-specific patterns of mineral lick use by white-tailed deer (*Odocoileus virginianus*). American Midland Naturalist 148: 289–296.

Ayotte, J. B., K. L. Parker, J .M. Arocena, and **M. P. Gillingham.** 2006. Chemical composition of lick soils: functions of soil ingestion by four ungulate species. Journal of Mammalogy 87: 878–888.

Comer, P., D. Faber-Langendoen, R. Evan, S. Gawler, C. Josse, G. Kittel, S. Menard., M. Pyne, M. Reid, K. Schulz, K. Snow, and **J. Teague.** 2003. Ecological systems of the United States: a working classification of U.S. terrestrial systems. NatureServe, Arlington, Virginia.

Côté, S. D., and **C. Beaudoin.** 1997. Grizzly bear (*Ursus arctos*) attacks and nanny-kid separation on mountain goats (*Oreamnos americanus*). Mammalia 61: 614–617.

Cowan, I. McT., and **V. C. Brink.** 1949. Natural game licks in the Rocky Mountain national parks of Canada. Journal of Mammalogy 30: 279–397.

Dormaar, J. F., and **B. D. Walker.** 1996. Elemental content of animal licks along the eastern slopes of the Rocky Mountains in southern Alberta, Canada. Canadian Journal of Soil Science 76: 509–512.

Festa-Bianchet, M. 1988. Birthdate and survival in bighorn lambs (*Ovis canadensis*). Journal of Zoology 214: 653-661.

Festa-Bianchet, M., and **S. D. Côté.** 2008. Mountain Goats: Ecology, Behavior, and Conservation of an Alpine Ungulate. Island Press. Washington D.C., USA.

Festa-Bianchet, M., M. Urquhart, and **K. G. Smith.** 1994. Mountain goat recruitment: kid production and survival to breeding age. Canadian Journal of Zoology 72: 22–27.

Foley, W. J., S. McLean, and **S. J. Cork.** 1995. Consequences of biotransformation of plant secondary metabolites on acid-base metabolism in mammals—a final common pathway? Journal of Chemical Ecology 21: 721-743.

Fox, J. L., C. A. Smith, and **J. W. Schoen.** 1989. Relation between mountain goats and their habitat in southeastern Alaska. General Technical Report PNW-GTR-246, U.S. Department of Agriculture and Forest Service, Pacific Northwest Research Station, Portland, Oregon, USA.

Fraser, D., and **H. Hristienko.** 1981. Activity of moose and white-tailed deer at mineral springs. Canadian Journal of Zoology 59: 1991–2000.

Hebert, D., and **I. McT. Cowan.** 1971. Natural salt licks as part of the ecology of the mountain goat. Canadian Journal of Zoology 49: 605–610.

Heimer, W. E. 1974. The importance of mineral licks to Dall sheep in interior Alaska and its significance to sheep management. Biennial Symposium of the Northern Wild Sheep and Goat Council 3: 49–64.

Heimer, W. E. 1988. A magnesium-driven hypothesis of Dall sheep mineral lick use: preliminary tests and management relevance. Biennial Symposium of the Northern Wild Sheep and Goat Council 6: 269–279.

Hnilicka, P., J. Mionczynski, B. Mincher, J. States, M. Hinschberger, S. Oberlie, C. Thompson, and **B. Yates.** 2002. Bighorn sheep lamb survival, trace minerals, rainfall and air pollution: Are there any connections? Northern Wild Sheep and Goat Council 13: 69–94.

Jones, R. L., and **H. C. Hanson.** 1985. Mineral licks, geophagy, and biochemistry of North American ungulates. Iowa State University Press, Ames.

Kennedy, J. F., J. A. Jenks, R. L. Jones, and **K. J. Jenkins.** 1995. Characteristics of mineral licks used by white-tailed deer (*Odocoileus virginianus*). American Midland Naturalist 134: 324–331.

Klaus, G., and **B. Schmid.** 1998. Geophagy at natural licks and mammal ecology: A review. Mammalia 62: 481–497.

Klein, D. R., and **H. Thing.** 1989. Chemical elements in mineral licks and associated muskoxen feces in Jameson Land, northeast Greenland. Canadian Journal of Zoology 67: 1092–1095.

Kreulen, D. A. 1985. Lick use by large herbivores: a review of benefits and banes of soil consumption. Mammal Review 15: 107–123.

Lewis, J. S., J. L. Rachlow, E. O. Garton, and **L. Vierling.** 2007. Effects of habitat on GPS collar performance: using data screening to reduce location error. Journal of Applied Ecology 44: 663-671.

Mincher, B. J., R. D. Ball, T. P. Houghton, J. Mionczynski, and **P. A. Hnilicka.** 2008. Some aspects of geophagia in Wyoming bighorn sheep (*Ovis canadensis*). Wildlife Research 54: 193–198.

Moe, S. R. 1993. Mineral content and wildlife use of soil licks in southwestern Nepal. Canadian Journal of Zoology 71: 933–936.

Poole, K. G., K. D. Bachmann, and **I. E. Teske.** 2010. Mineral lick use by GPS radio-collared mountain goats in southeastern British Columbia. Western North American Naturalist 70:208-217.

Poole, K. G., and **D. C. Heard.** 2003. Seasonal habitat use and movements of mountain goats, *Oreamnos americanus*, in east-central British Columbia. Canadian Field-Naturalist 117: 565–576.

Rice, C. G. 2008. Seasonal altitudinal movements of mountain goats. Journal of Wildlife Management 72: 1706–1716.

Rice, C. G., and **B. Hall.** 2007. Hematologic and biochemical reference intervals for mountain goats (*Oreamnos americanus*): effects of capture conditions. Northwest Science 81: 206–214.

Rice, C. G., K. J. Jenkins, and **W. Chang.** 2009. A sightability model for mountain goats. Journal of Wildlife Management 73: 468–478.

SAS Institute. 2007. JMP User Guide, Release 7. SAS Institute, Cary, North Carolina, USA.

Singer, F. J., and **J. L. Doherty.** 1985. Movements and habitat use in an unhunted population of mountain goats, *Oreamnos americanus*. Canadian Field-Naturalist 99: 205–217.

Tankersley, N. G. 1984. Mineral lick use by Dall sheep in the Watana Creek Hills, Alaska. Biennial Symposium of the Northern Wild Sheep and Goat Council 4: 211–230.

Tankersley, N. G., and **W. C. Gasaway.** 1983. Mineral lick use by moose in Alaska. Canadian Journal of Zoology 61: 2242–2249.

Tracy, B. F., and **S. J. McNaughton.** 1995. Elemental analysis of mineral lick soils from the Serengeti National Park, the Konza Prairie and Yellowstone National Park. Ecography 18: 91–94.

Turney, L., and **R. Blume.** 2004. Daily and seasonal movement patterns of mountain goats to a mineral lick in north-central British Columbia. Biennial Symposium of the Northern Wild Sheep and Goat Council 14: 64.

Weeks, H. P., Jr., and **C. M. Kirkpatrick.** 1976. Adaptations of white-tailed deer to naturally occurring sodium deficiencies. Journal of Wildlife Management 40: 610–625.

Wells, A. 2006. Global Positioning System (GPS) Bias Correction and Habitat Analysis of Mountain Goats Oreamnos americanus in the Cascades of Washington State, USA M. Sc. Thesis, Western Washington University, Bellingham.

Wiles, G. J., and **H. P. Weeks, Jr.** 1986. Movements and use patterns of white-tailed deer visiting natural licks. Journal of Wildlife Management 50: 487–496.

Wright, W. 1977. Ecology of the Cascade Mountain Goat, Mount Baker-Snoqualmie National Forest, Washington. M.Sc. Thesis, Western Washington State University, Bellingham.

Zar, J. H. 1996. Biostatistical Analysis. 3rd edition. Prentice Hall, Upper Saddle River.

Received 24 June 2010
Accepted 27 September 2010

Further to the Occurrence of Red Abalone, *Haliotis rufescens,* in British Columbia

N. A. Sloan[1], D. C. McDevit[2], and G. W. Saunders[2]

[1] Gwaii Haanas National Marine Conservation Area Reserve and Haida Heritage Site, Box 37, Queen Charlotte, British Columbia V0T 1S0 Canada; corresponding author: norm.sloan@pc.gc.ca

[2] Centre for Environmental and Molecular Algal Research, Department of Biology, University of New Brunswick, Fredericton, New Brunswick E3B 5A3 Canada

Sloan, N. A., D. C. McDevit, and G. W. Saunders. 2010. Further to the occurrence of Red Abalone, *Haliotis rufescens,* in British Columbia. Canadian Field-Naturalist 124(3): 238–241.

We report on additional occurrences of Red Abalone (*Haliotis rufescens* Swainson, 1822) that bring the total to seven from British Columbia coastal waters. Possible causes of the presence of Red Abalone include northward (winter) transport via kelp rafts from the Oregon-California area. We tested this hypothesis by performing DNA barcoding analyses on a fragment of kelp holdfast on the surface of one such shell establishing its identity as *Nereocystis luetkeana* (Mertens) Postels & Ruprecht – a giant kelp with a hollow stipe terminating in a bulbous pneumatocyst (gas-filled float). The occurrence of Red Abalone due to natural processes, besides being important biogeographically, has had important implications for indigenous peoples' pre- and post-contact trade and material culture.

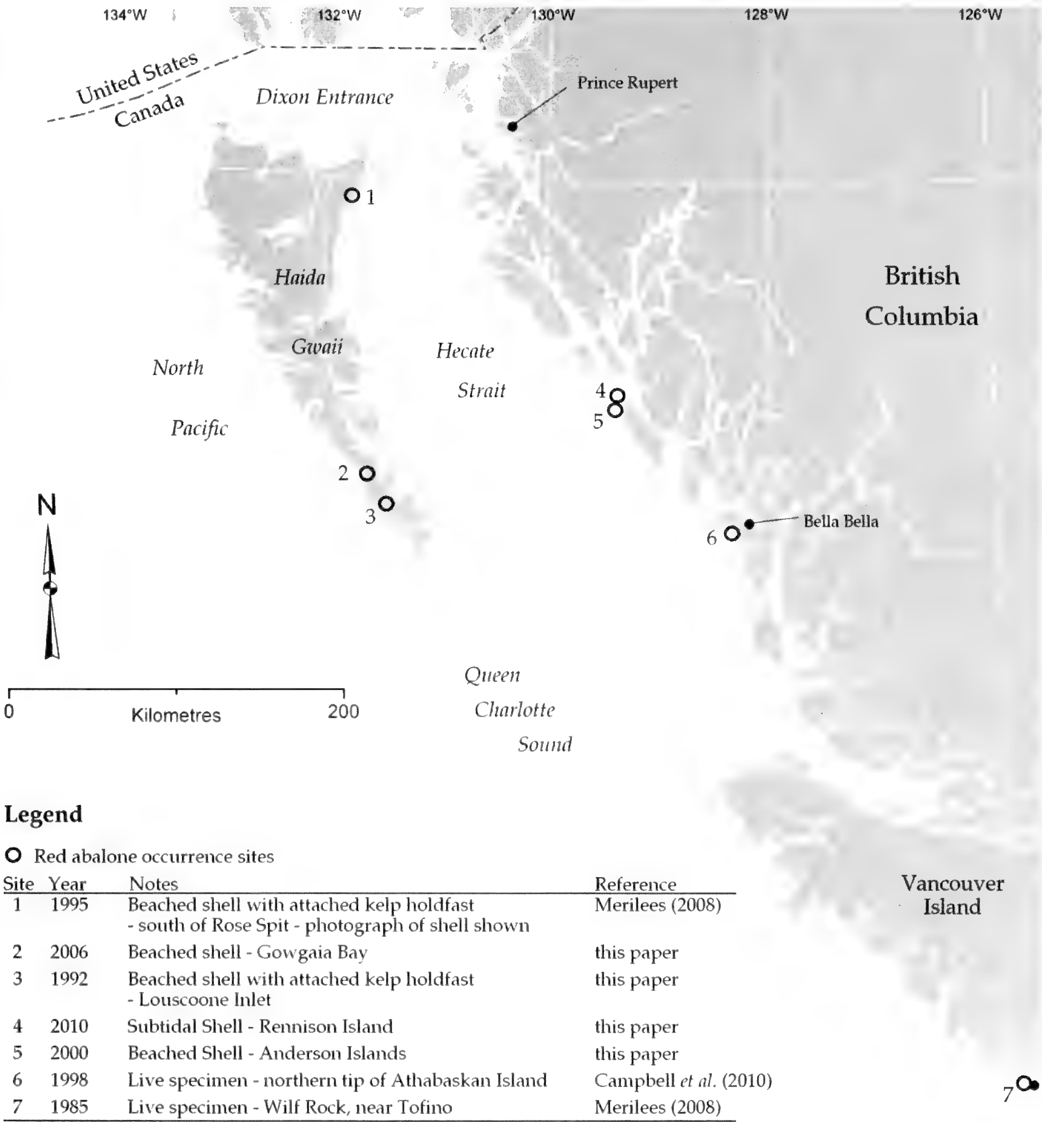
Key Words: Red Abalone, *Haliotis rufescens,* Northern Abolone, *Haliotis kamtschatkana*, giant kelp, *Nereocystis leutkeana*, indigenous people, Haida Gwaii, British Columbia.

A live purebred Red Abalone (*Haliotis rufescens* Swainson, 1822) was confirmed from British Columbia coastal waters (Campbell et al. 2010). The only resident abalone species from British Columbia was previously considered to be the Northern Abalone (*Haliotis kamtschatkana* Jonas, 1845) (Geiger 2000; Sloan 2004). Another live Red Abalone, and a beached shell, have also recently been recorded from British Columbia (Merilees 2008). These confirm a significant range extension, as the northern limit for Red Abalone was recorded as the Oregon area (Geiger 2000). We recount four more shells of Red Abalone from British Columbia, reflect upon possible causes and discuss implications for indigenous trade and material culture.

Illustrated in Figure 1 are seven confirmed locations of Red Abalone in British Columbia, all within the last 25 years and separated by more than 600 km. The two beached shells from the southwest coast of Haida Gwaii (Queen Charlotte Islands), are shown in Figure 2. It is interesting that recreational diving, the diving commercial fisheries for Northern Abalone (*Haliotis kamtschatkana)* that occurred until its closure in 1990, and on-going coast-wide diving fisheries for sea urchins (*Strongylocentrotus* species) and Geoduck Clam (*Panope abrupta*) yielded no reports of Red Abalone. Further, over 30 years of government population surveys for Northern Abalone coastwide have also not documented Red Abalone (Campbell et al. 2010).

Speculation on how Red Abalone got to British Columbia includes northward range extension influenced by climate change (ocean warming) and human intervention relating to aquaculture, as discussed by Campbell et al. (2010). Merilees (2008) suggested northward transport via kelp rafts from the Oregon-California area. This is intriguing because kelp holdfasts on two of the shells listed in Figure 1 could indicate transport by drift kelp (discussed below). A live abalone has been seen attached to a holdfast in drift Bull Kelp (*Nereocystis luetkeana*) off northern California (J. Kashiwada, California Department of Fish and Game, personal communication). Violent winter storms can dislodge enormous quantities of kelp from rocky California reefs (Tegner et al. 1997). Further, currents run northward along the Pacific coast in winter and Merilees (2008) speculated that Haida Gwaii could be reached in six to eight weeks from southern Oregon.

If kelp rafting does explain the discovery of Red Abalone in northern British Columbia, then remnants of holdfasts on these shells would likely derive from the pneumatocyst – (large gas containing floats) bearing kelp such as *Macrocystis* or *Nereocystis*. To test this hypothesis, we generated sequence for the 5' region of the mitochondrial cytochrome c oxidase 1 (COI-5P) gene, the standard DNA barcode marker in red and brown algae (Saunders 2005; McDevit and Saunders 2009), from a holdfast fragment on the shell from Louscoone Inlet, following McDevit and Saunders (2009). The protocols were completed with modifications to reduce possible contamination: all procedures were completed in isolation of other collections; a blank was included (no sample, but tube taken through all stages including DNA extraction, PCR, except sequencing [there was not a PCR product]) were included in addition to the standard negative control used in PCR; and the entire process was completed in duplicate. All blanks and negative controls were clean and all posi-



Legend

O Red abalone occurrence sites

Site	Year	Notes	Reference
1	1995	Beached shell with attached kelp holdfast - south of Rose Spit - photograph of shell shown	Merilees (2008)
2	2006	Beached shell - Gowgaia Bay	this paper
3	1992	Beached shell with attached kelp holdfast - Louscoone Inlet	this paper
4	2010	Subtidal Shell - Rennison Island	this paper
5	2000	Beached Shell - Anderson Islands	this paper
6	1998	Live specimen - northern tip of Athabaskan Island	Campbell *et al.* (2010)
7	1985	Live specimen - Wilf Rock, near Tofino	Merilees (2008)

FIGURE 1. Locations with notes about occurrences of live Red Abalone, or their shells, around British Columbia.

tive tests resulted in a COI-5P sequence assignable to *Nereocystis luetkeana*, which is consistent with our initial hypothesis. The resulting sequence was deposited in the Barcode of Life Data Systems (BOLD – www.boldsystems.org) as accession MACRO2982-10.

Unfortunately, whereas COI-5P is an excellent species-discriminating tool in brown algae (e.g., McDevit and Saunders 2009, 2010) it is typically not sufficiently variable to facilitate population level analyses and thus to determine the provenance of the kelp holdfast fragment and the putatively co-transported shell. We anticipate that, owing to the generally low levels of molecular diversity typical of floating kelp (e.g., *Macrocystis*; Coyer et al. 2001), microsatellites will need to be developed to address this question (e.g., Alberto et al. 2009). Only a few studies have actually looked at the transportation of kelp rafts, these typically confined to local scales and focused on *Macrocystis* (e.g., Harrold and Lisin 1989), but results indicate continued zoospore production and germination over extended periods of time (Hernández-Carmona et al. 2006), which could contribute to a reduction of genetic structure. Considering the putative distance that this plant has travelled (Oregon? to northern British Columbia), it could be that *Nereocystis* has little population structure along the coast of North America (although see

FIGURE 2. Two beached Red Abalone shells collected from Haida Gwaii, British Columbia. The top shell is from Gowgaia Bay (shell length 200 mm) and the bottom shell is from Louscoone Inlet (shell length 235 mm).

evidence to the contrary for *Macrocystis* [Alberto et al. 2010]). Regardless, our results potentially record the longest distance travelled by an individual of *Nereocystis luetkeana* (ca. 1000 km), assuming that the putatively co-transported abalone shell derived from its native range in Oregon or further south.

If northward transport of kelp rafts occurs, then the British Columbia coast could have received kelp-transported live Red Abalone or their shells in prehistory. This would have provided indigenous peoples coast-wide with abalone shell that was, and still is, used for personal adornment and decoration such as carving inlay (Dubin 1999; Sloan 2003). The shells of large abalone species, such as Red Abalone, were preferred for cultural use coast-wide compared to the smaller and thinner local Northern Abalone shell (Sloan 2003).

On Haida Gwaii, the Haida people (the only indigenous group) traded for abalone shell with the Spanish (from the California area) at the first recorded contact in July 1774 (Sloan 2003). American and British Sea Otter (*Enhydra lutris*) fur traders used abalone shell as a commodity and abalone shell was in wide circulation along the coast and well into the interior. This post-contact abalone shell exchange flourished with the Sea Otter fur trade that peaked from the 1790s to the 1830s. There is also the prospect of pre-contact abalone shell trade coast-wide (Dubin 1999, page 429). Haida traditional (oral) knowledge asserts that Haida canoed far south and acquired abalone shell in pre-contact intertribal trade (Cove 1985, page 143; B. Wilson, Gwaii Haanas, personal communication). Indeed, the British Columbia area marine shell trade, for a range of species, goes back over 6000 years (Carlson 1994). If Red Abalone shells came ashore attached to kelp, perhaps over centuries, it would be difficult to differentiate between shell acquired through pre-contact trade, post-contact trade or beach-gathering. There is therefore, besides the inherent biogeographic interest, an important cultural dimension to the presence of Red Abalone in British Columbia.

Acknowledgments

Heartily thanks to K. Hansen and H. Wier for sharing the Gowgaia Bay and Louscoone Inlet shells respectively. P. Bartier and C. Johnson kindly provided the figures. The on-going support of Gwaii Haanas management is gratefully acknowledged. Molecular aspects of this research were supported through funding to the Canadian Barcode of Life Network from Genome Canada through the Ontario Genomics Institute, NSERC and other sponsors listed at www.BOLNET.ca. Additional support was provided by the Canada Research Chair Program, the Canada Foundation for Innovation and the New Brunswick Innovation Foundation.

Literature Cited

Alberto, F., A. Whitmer, N. C. Coelho, M. Zippay, E. Varela-Alvarez, P. T. Raimondi, D. C. Reed, and **E. A. Serrao.** 2009. Microsatellite markers for the giant kelp *Macrocystis pyrifera*. Conservation Genetics 10: 1915-1917.

Alberto, F., P. T. Raimondi, D. C. Reed, N. C. Coelho, R. Leblois, A. Whitmer, and **E. A. Serrao.** 2010. Habitat continuity and geographic distance predict population genetic differentiation in giant kelp. Ecology 91: 49-56.

Campbell, A., R. E. Withler, and **K. J. Supernault**. 2010. Occurrence of the red abalone (*Haliotis rufescens*) in British Columbia, Canada. American Malacological Bulletin 28: 185-188.

Carlson, R. L. 1994. Trade and exchange in prehistoric British Columbia. Pages 307-361 *in* Prehistoric Exchange Systems in North America. *Edited by* T. G. Baugh and J. E. Ericson. Plenum Press, New York.

Cove, J. J. 1985. A detailed inventory of the Barbeau northwest coast files. B-F-251.17. National Museum of Man, Mercury Series, Canadian Centre for Folk Culture Studies Paper 54. 260 pages. Ottawa.

Coyer, J. A., G. J. Smith, and **R. A. Andersen.** 2001. Evolution of *Macrocystis* spp. (Phaeophyceae) as determined by ITS1 and ITS2 sequences. Journal of Phycology 37: 574-585.

Dubin, L. S. 1999. North American Indian jewellery and adornment from prehistory to present. Harry N. Abrahams, New York. 608 pages.

Geiger, D. L. 2000. Distribution and biogeography of the recent Haliotidae (Gastropoda: Vetigastropoda) world-wide. Bollettino Malacologico, Roma 35: 57-120.

Harrold, C., and **S. Lisin.** 1989. Radio-tracking rafts of giant kelp: local production and regional transport. Journal of Experimental Marine Biology and Ecology 130: 237-251.

Hernández-Carmona, G., B. Huhges, and **M. H. Graham.** 2006. Reproductive longevity of drifting kelp *Macrocystis pyrifera* (Phaeophyceae) in Monterey Bay, USA. Journal of Phycology 42: 1199-1207.

McDevit, D. C., and **G. W. Saunders.** 2009. On the utility of DNA barcoding for species differentiation among brown macroalgae (Phaeophyceae) including a novel extraction protocol. Phycological Research 57: 131-141.

McDevit, D. C., and **G. W. Saunders.** 2010. A DNA barcode examination of the Laminariaceae (Phaeophyceae) in Canada reveals novel biogeographical and evolutionary insights. Phycologia 49: 235-248.

Merilees, B. 2008. Records of the red abalone in British Columbia. Victoria Naturalist 65(3): 11.

Saunders, G. W. 2005. Applying DNA barcoding to red macroalgae: a preliminary appraisal holds promise for future applications. Philosophical Transactions of the Royal Society B: Biological Sciences 360: 1879-1888.

Sloan, N. A. 2003. Evidence of California-area abalone shell in Haida trade and culture. Canadian Journal of Archaeology 27: 273-286.

Sloan, N. A. 2004. Northern abalone: Using an invertebrate to focus marine conservation ideas and values. Coastal Management 32: 129-143.

Tegner, M. J., P. K. Dayton, P. B. Edwards, and **K. L. Riser.** 1997. Large-scale, low-frequency oceanographic effects on kelp forest succession: A tale of two cohorts. Marine Ecology Progress Series 146: 117-134.

Received 13 August 2010
Accepted 22 October 2010

Scavenging of an Elk, *Cervus elaphus*, Carcass by Multiple Cougars, *Puma concolor*, in Southeastern Alberta

MICHELLE M. BACON and MARK S. BOYCE

Department of Biological Sciences, University of Alberta, Edmonton, Alberta T6G 2E1 Canada; e-mail: mmbacon@ualberta.ca: boyce@ualberta.ca

Bacon, Michelle M., and Mark S. Boyce.2010. Scavenging of an Elk, *Cervus elaphus*, carcass by multiple Cougars, *Puma concolor*, in southeastern Alberta. Canadian Field-Naturalist 124(3): 242–245.

We report the confirmed or suspected scavenging by six different Cougars, *Puma concolor*, on an Elk (*Cervus elaphus*) carcass, from January to April 2009, near Cypress Hills Interprovincial Park in southeastern Alberta, Canada. Visitations by Cougars were captured by a camera trap focused on the carcass; we were able to tentatively identify 6 individual Cougars by the presence of radio-collars, ear sizes and tail characteristics. Our photos are the first published event of >2 Cougars feeding on the same carcass.

Key Words: Cougar, *Puma concolor*, camera trap, scavenging, food sharing, Alberta.

Scavenging by cougars (*Puma concolor*) has rarely been reported, and most long-term studies suggest that they prefer to kill their own prey. For example, Ross and Jalkotzy (1996) found only four incidents of scavenging on Moose (*Alces alces*) carcasses during their 13-year study in southwestern Alberta; similarly, Logan and Sweanor (2001) reported only 16 cases of scavenging in their 10-year study in New Mexico. However, a few observations of Cougar scavenging have been reported, including an adult female scavenging on Elk (*Cervus elaphus*) carcasses during a 22-day period in northeast Oregon (Nowak et al. 2000). More recently, Bauer et al. (2005) reported 20 of 46 (43.5%) Mule deer (*Odocoileus hemionius*) carcasses they placed out as bait in California were scavenged by Cougars. Knopff et al. (2010) reported that the tendency for Cougars to scavenge in west-central Alberta is high, making them vulnerable to baited snares along traplines set for Wolves (*Canis lupus*) or Coyotes (*Canis latrans*); incidental snaring was responsible for 11% of Cougar mortalities during their four-year study.

Even with the advent of Global Positioning Systems (GPS) radiocollars and cluster techniques to locate kill sites (Anderson and Lindzey 2003; Knopff et al. 2009), Cougar scavenging events and rates are difficult to quantify. Previous studies (Bauer et al. 2005) have shown that Cougars will treat scavenged carcasses similar to their own kills, and will cache and cover them with vegetation and soil. A carcass might be scavenged by numerous species, including Coyotes, birds and small mammals, before researchers can visit it, making it a challenge to determine with confidence if the Cougar had killed the prey. Scavenging that is confused with kills could inadvertently inflate estimated kill rates (Bauer et al. 2005; Knopff et al. 2010). Most reports of Cougar scavenging have either noted scavenging by a single Cougar on a carcass, or they do not or can not distinguish between individual Cougars. Here, we report scavenging of a single Elk carcass by multiple Cougars, captured on camera traps in southeastern Alberta.

On 6 January 2009, we were notified by a landowner of Cougar tracks and scat around the carcass of an adult bull Elk, approximately 350m south of Cypress Hills Interprovincial Park, a protected area straddling the Alberta-Saskatchewan border (49°40'N, 110°15'W). Here, Cougars naturally re-established a population during the mid 2000s (Bacon and Boyce 2009). We visited the frozen Elk carcass the following day, and confirmed that it did not exhibit the typical signs of a Cougar kill (e.g., consumed organs, caching the carcass and covering it with vegetation and hair piles). There were no fresh Cougar tracks upon initial investigation, and we concluded that scavenging was initiated by Coyotes and various birds. Elk hunting occurred in the area in late November 2008 (D. Mitzner, personal communication), and it was likely then that the Elk was wounded.

We placed a Reconyx RC55 RapidFire camera (Reconyx, Inc., Holman, WI, USA) in a tree approximately 1 m above the ground and 3 m from the carcass. A second camera trap (Stealth Cam, LLC, Grand Prairie, Texas, USA) was set up on a game trail leading away from the carcass by the landowner for the month of January. The Reconyx camera took 3845 photos between 7-13 January 2009 before the memory card filled. We checked the camera on 30 January 2009 and reprogrammed it to take fewer pictures per motion event; however, largely due to the frequent activities of Black-billed Magpies (*Pica hudsonia*), the memory card filled within four days. We checked and reset the camera on 12 March 2009; the camera took 3734 photos before filling up the memory card on 3 April 2009. We removed the camera on 17 April 2009 once the carcass was mostly consumed. In total, the Reconyx camera trap was operational for 34 days of 101 days

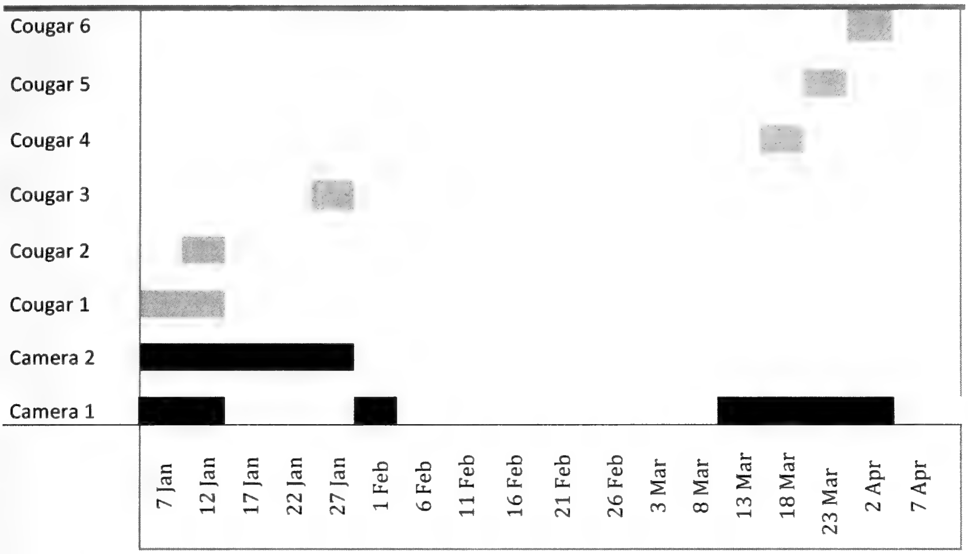


FIGURE 1. Timeline showing days that Reconyx and Stealthcam cameras were active, and days individual Cougars were recorded.

it was deployed (34 %) between 7 January 2009 and 17 April 2009 (Figure 1).

Cougars in our study area had frequently lost the tips of the ears or the black tips of their tails, likely from frostbite. These traits, along with body size and morphology, and the presence or absence of a radio-collar, allowed us to tentatively identify six individual Cougars that visited the Elk carcass during the 3.5 months that the camera traps were deployed. Photographic evidence showed that three of these Cougars fed on the carcass, while another three visited the carcass and may have fed on it, but we could not confirm this with our photos.

Cougar 1 was our most frequent visitor to the carcass and spent the most time scavenging on the carcass (Figure 2). She had very short ears, a full tail, and no radiocollar, and her body size and configuration indicated she was a female. Cougar 1 was first captured on the camera on 8 January 2009 and spent much of the following 6 days eating, grooming and sleeping next to the carcass. She scavenged on the carcass at all times of day, and several series of photos showed her covering the carcass with soil and vegetation. She was last photographed on 13 January 2009.

Cougar 2 appeared while Cougar 1 was still feeding on the carcass (Figure 2), although Cougar 2 was never photographed at the carcass at the same time as Cougar 1. Cougar 2 was smaller than Cougar 1 and had no radio-collar, but had very large ears and a full tail. Based on body size, Cougar 2 was probably a juvenile. Cougar 2 was never observed consuming meat from the carcass; each of the four times it appeared between 11-13 January 2009, it sniffed the Elk, walked around the carcass and then left. This Cougar might not have eaten anything from the Elk possibly because Cougar 1, an adult, was still using the carcass and likely marking it with urine or scat. Cougar 2 also was captured on the camera trap on the trail leading away from the carcass on 14 January 2009, the day after the camera at the carcass ran out of memory.

Cougar 3 was photographed by the camera trap on the trail on 26 January 2009, during a period when the camera trap on the carcass was not working (Figure 2). This Cougar had full ears, a short tail and possibly a radio-collar. After examining GPS data from our radio-collared females (M. Bacon and M. Boyce, unpublished data), we confirmed that an individual had been in that area but not long enough to conclude with certainty that she had been scavenging on the carcass.

Cougar 4 was a radio-collared adult female that was easily identified from her half-length tail. She arrived at the carcass on 19 March 2009 and scavenged for 30 min before leaving. She returned 11 days later but did not feed on the carcass (Figure 2).

Cougar 5 was first photographed on 23 March 2009. This Cougar had a significantly larger body and head than any other cougar that we photographed on this camera, and it was clearly an adult male. He ate sparingly from the carcass and was not photographed again (Figure 2).

Cougar 6 was a radio-collared female with full ears and a full tail (Figure 2). She was a young female and we would later find other incidents of scavenging on

FIGURE 2 a-f. Six individual Cougars can be identified visiting and/or scavenging on the elk carcass between January 7-April 17 2009.

Elk and Moose by her as well. She was first photographed at the carcass on 2 April 2009 and ate throughout that day and the next, despite the fact that little meat remained on the carcass. She left the carcass frequently and covered it when she left between scavenging events. The camera's memory card filled on 3 April 2009, but GPS data from her radiocollar showed that she remained at the carcass until the morning of 8 April 2009 (M. Bacon and M. Boyce, unpublished data). She returned to the carcass repeatedly during 21-28 April 2009.

Our use of motion-activated camera traps confirmed scavenging activity as well as the use of a single carcass by multiple Cougars during a relatively short time frame. We think it unlikely that this was a unique event; Cougars may be chasing other intra- and interspecific competitors off fresh and scavenged kills frequently, which could inflate estimated predation rates. Cougars

of varied age-classes and both sexes scavenged the carcass. All six Cougars that visited and/or scavenged on the Elk carcass appeared to be in healthy condition, and we know the three with radiocollars were all capable of killing their own prey because we had located kill sites using GPS cluster techniques (Bacon and Boyce 2009). Our photographs add to the other recent observations (e.g., Nowak et al. 2000; Bauer et al. 2005; Knopff et al. 2010) that scavenging may be a more important foraging strategy in Cougars than previously recognized.

Acknowledgments

We are grateful to D. Mitzner for identifying Cougar tracks and allowing us access to his land. We thank all field technicians for assistance in data collection. Funding was provided by Alberta Tourism, Parks and Recreation, Saskatchewan Environment, Alberta Conservation Association, Alberta Sport Recreation Parks and Wildlife Foundation, Medicine Hat Fish and Game Association, Canadian Wildlife Federation, TD Friends of Environment, Heritage Association of Cypress Hills, Safari Club International-Northern Alberta Chapter and The Lions Club. We thank Cypress Hills Interprovincial Park for in-kind and logistical support during field work.

Literature Cited

Anderson Jr., C. R., and **F. G. Lindzey.** 2003. Estimating cougar predation rates from GPS location clusters. Journal of Wildlife Management 67: 307-316.

Bacon, M. M., and **M. S. Boyce.** 2009. The prairie cougar: Examining the effects of a re-established predator population. Nature Alberta 38: 20-23.

Bauer, J. W., K. A. Logan, L. L. Sweanor, and **W. M. Boyce.** 2005. Scavenging behaviour in Puma. Southwestern Naturalist 50: 466-471.

Knopff, K. H., A. A. Knopff, and **M. S. Boyce.** 2010. Scavenging makes cougars susceptible to snaring at wolf bait stations. Journal of Wildlife Management 74: 644-653.

Knopff, K. H., A. A. Knopff, M. B. Warren, and **M. S. Boyce**. 2009. Evaluating global positioning system telemetry techniques for estimating cougar predation parameters. Journal of Wildlife Management 73: 586-597.

Logan, K. A., and **L. L. Sweanor.** 2010. Behaviour and social organization of a solitary carnivore. Pages 105-117 *in* Cougar ecology and conservation. *Edited by* M. Hornocker and S. Negri, University of Chicago Press, Chicago, USA.

Logan, K. A., and **L. L. Sweanor.** 2001. Desert Puma: evolutionary ecology and conservation of an enduring carnivore. Island Press, Washington DC, USA.

Nowak, M. C., T. E. Taylor, and **G. W. Witmer.** 2000. Prolonged scavenging by a female mountain lion in northeastern Oregon. Northwestern Naturalist 81: 63-65.

Quigley, H., and **M. Hornocker.** 2010. Cougar population dynamics. Pages 59-75 *in* Cougar ecology and conservation. *Edited by* M. Hornocker and S. Negri, University of Chicago Press, Chicago, USA.

Ross, I. P., and **M. G. Jalkotzy**. 1996. Cougar predation on moose in southwestern Alberta. Alces 32: 1-8.

Received 5 September 2010
Accepted 19 November 2010

An Analysis of the Distribution, Ecology, and Status of Bugseeds (*Corispermum*) in Canada

DIANA BIZECKI ROBSON

The Manitoba Museum, 190 Rupert Avenue, Winnipeg, Manitoba R3B 0N2 Canada; e-mail: drobson@manitobamuseum.ca

Robson, Diana Bizecki. 2010. An analysis of the distribution, ecology, and status of bugseeds (*Corispermum*) in Canada. Canadian Field-Naturalist 124(3): 246–255.

The bugseeds (*Corispermum* spp.) are a genus of annual plants that are uncommon due to their psammophilic, ruderal habit. Bugseeds are typically found in natural areas with some bare sand, like sand dunes, but are also present in anthropogenically impacted sandy or gravelly areas. Increasing dune stabilization may be causing the endangerment of some Bugseed species. Assessing the rarity of the five species in Canada is hindered by the lack of recently collected specimens and the use of out-dated nomenclature in herbaria. Specimens of bugseeds from major herbaria all across Canada were examined and re-identified using the most recent taxonomic treatment in the Flora of North America. Hairy Bugseed (*C. villosum*) was the most commonly collected taxon and Hooker's Bugseed (*C. hookeri* var. *pseudodeclinatum*) the rarest. The natural distribution of all taxa, except Alaskan Bugseed (*C. ochotense*) which is only found in the far north, is from British Columbia to Ontario. Hairy, Hooker's and American Bugseed (*C. americanum*) are also found in Quebec, where they may have been introduced from further west. Summaries of Bugseed localities and habitats, and distribution maps are presented to facilitate the status assessment of plants in this genus.

Key Words: bugseeds, *Corispermum*, distribution, habitat, psammophile, status, Canada.

The bugseeds (*Corispermum* spp.) are a genus of annual plants that favour sandy and gravelly glaciofluvial soils (Welsh et al. 2003). Initial taxonomic treatments and floras considered there to be only three species of European-introduced *Corispermum* in all of North America, namely *C. hyssopifolium* L., *C. nitidum* Kit. and *C. orientale* Lam (Maihle and Blackwell 1978). However, recent research on the genus, including palaeobotanical evidence (Betancourt et al. 1984; Matthews et al. 1990), suggests that most of the species found in North America are native and unrelated to European flora, sharing a closer affinity with eastern Asian species (Mosyakin 1995). In fact, two species found in Canada, Alaskan Bugseed (*C. ochotense* Ignatov) and Pallas Bugseed (*C. pallasii* Steven) are now recognized as being native in eastern Asia as well as North America (Mosyakin 1995; Welsh et al. 2003). Three additional species found in Canada, Hooker's Bugseed (*C. hookeri* Mosyakin), American Bugseed (*C. americanum* (Nuttall) Nuttall) and Hairy Bugseed (*C. villosum* Rydberg), are considered to be native to North America, with the former one being endemic to Canada (Welsh et al. 2003). Thus the original scientific names that Canadian *Corispermum* specimens were assigned are now incorrect. Due to a lack of resources many regional herbaria in Canada had not completely updated the nomenclature of their Bugseed specimens; a mixture of old and new names were being used. This in turn made assessment of the status of these species difficult since only a limited number of specimens were identified correctly.

To facilitate status assessment I examined Bugseed specimens from all major herbaria in Canada and re-identified them to the most recent nomenclature. This article summarizes the distribution, habitat and status of the Bugseed genus in Canada.

Methods

Herbarium specimens from 20 herbaria in Canada (see Acknowledgments for a complete list) were borrowed and examined. A total of 499 specimens were looked at; of those specimens 267 had already been annotated to the nomenclature in Flora of North America (Welsh et al. 2003) by nine different botanists, mostly S. Mosyakin, author of the most recent *Corispermum* taxonomic treatment (Mosyakin 1995), J. Cayouette (Curator at DAO) and V. L. Harms (retired Curator at SASK). I annotated 232 of the specimens that still possessed old synonyms by using the keys and species descriptions in Welsh et al. (2003) and comparing the specimens to those that had been annotated by Mosyakin. Measurements of seeds using callipers were often required to identify the specimens. There were 31 specimens that could not be confidently identified to species as they were too immature. One specimen of Alaskan Bugseed from the Harvard University Herbarium was not actually observed but as the label data was available in Cody et al. (2003), the information was included in this study. Contrary to previous keys (Scoggan 1956, 1978; Looman and Best 1979; Moss 1983), the hairiness of the plants is not a reliable character for distinguishing Bugseed species; it is the shape and dimensions of the fruits and wings, and the density of the inflorescences that are the most important characters (Mosyakin 1995; Sukhorukov 2007). For this reason identification of Bugseed species is

difficult when the plant is immature as fruits are generally needed for positive identification.

To facilitate the production of summary data and distribution maps, all label information from each specimen was recorded into a spreadsheet. To prepare the distribution maps, a latitude and longitude for each specimen was obtained. Geographic co-ordinates were available for 29% of the specimens, either obtained directly by the original collector or derived from the label information by the staff at the herbaria housing the specimens. To obtain a latitude and longitude for 14 specimens with a legal land description only, the midpoint of the legal subdivision, quarter or half section, or section was obtained using a geographic conversion website (http://legallandconverter.com). No geographic co-ordinate was supplied by the collector for most specimens (71%). For these specimens, the locality name on the label was entered into the Atlas of Canada website (http://atlas.nrcan.gc.ca/site/english/maps/topo/map) search function and a latitude/longitude for that location recorded. Sometimes detailed locality descriptions (e.g., 5-6 miles east of Mortlach) could be used in conjunction with Atlas of Canada maps to pinpoint a more accurate location than using just a locality name co-ordinate. When multiple place names came up in the search, the locality and habitat description was used to help select the most likely location of the collected specimen. Thus the accuracy of the geographic co-ordinates is only approximate but likely within a 10-25 km radius. Ground truthing is necessary to confirm the existence of the species at those precise co-ordinates. Nonetheless, the maps give a good general idea of the species' known distributions in Canada.

To prepare the habitat summary, the descriptions recorded by the collector were used to group the habitats into one of three categories: natural areas not directly impacted by humans, anthropogenically impacted areas where humans had disturbed the soil in some manner and specimens with no recorded description. Natural areas were further divided into six categories: (1) riparian sand banks and dunes, (2) riparian sand bars, (3) inland sand dunes and blowouts, (4) inland sandy hills and cliffs, (5) inland sandy plains and (6) lacustrine beaches and dunes. Anthropogenically impacted areas were further divided into six categories: (1) cultivated fields, (2) railways, (3) sand and gravel pits, (4) sandy disturbed areas, (5) sandy fireguards and (6) sandy roadsides.

As the process to rank species is based at least partly on the number of localities (Canadian Endangered Species Conservation Council (CESCC) 2005*; NatureServe 2010*), the results of this study were used to recommend status changes for some taxa. Using the information from this assessment, I prepared suggested ranks using NatureServe (2010*) and CESCC (2005*) numerical codes, for the various species based on locality data (Table 4). Using the NatureServe (2010*) ranks, jurisdictions with fewer than five localities were given a rank of "1" or critically imperilled, those with 5 to 15 localities were given a rank of "2" or imperilled and those with 15 to 100 localities were given a rank of vulnerable. For the CESCC (2005*) ranks, no taxa were given a rank of "1" or "At Risk", as this designation implies that the taxa has already been protected under the *Species At Risk Act 2002*, or assessed by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC 2010*) or a provincial governing body. Therefore taxa with 15 or fewer localities were given a rank of "2" or "May Be At Risk" while those with 16 to 100 localities were given a rank of "3" or "Sensitive". All Bugseed species were considered "Sensitive" rather than "Secure" or "Vulnerable" given their presence in habitats that are known to be in decline (Hugenholtz and Wolfe 2005; Robson 2006).

Results

Distribution and Habitat

Although 499 herbarium specimens of Canadian bugseeds were examined, they represented only 272 localities as 228 of them appear to be duplicates (Table 1). Some of these locality duplicates were collected by the same person on the same date and distributed to herbaria all across the country, as was typical of collectors such as B. Boivin, H. J. Scoggan, G. Ledingham, R. Giroux, W. J. Cody, W. G. Dore and A. J. Breitung to name a few. The holotype of Hooker's Bugseed, which is located at the Department of Agriculture Herbarium (DAO), is one such specimen with isotypes located on nine herbaria in Canada and at least one in the U.S. (only two isotypes were known about when the species description was published by Mosyakin in 1995). Other locality duplicates were collected by two different people on two different dates but had the exact same (but often vague) locality description (e.g., Fort Saskatchewan, Alberta). The two specimens may not have been collected at the exact same location but without additional label information it is impossible to know. At 35 of the localities more than one species of Bugseed was found; at four localities — two in Saskatchewan, one in Alberta and one in Ontario-specimens of four Bugseed species were found.

Bugseed plants occur in eight ecozones from as far north as Aklavik, Northwest Territories south to the shore of Lake Erie, Ontario, and from Vancouver, British Columbia in the west to Quebec City, Quebec in the east. However, the vast majority (52%) of Bugseed localities are in the Prairie ecozone (Marshall and Schut 1999), which spans Alberta, Saskatchewan and Manitoba (Table 2). An additional 22% of the localities are in the Boreal Shield and Boreal Plain ecozones, which stretch from Newfoundland to eastern British Columbia. Canadian bugseeds have not been found along oceanic beaches and dunes in the Atlantic Maritime ecozone.

Bugseeds are most common in pioneer, marginal, and naturally and artificially disturbed soils high in sand

TABLE 1. Number of Bugseed (*Corispermum* spp.) localities and specimens (in brackets) from Canadian provinces/territories based on an examination of specimens in 20 Canadian herbaria.

	Province/Territory # localities (# specimens)								
Species	BC	AB	SK	MB	ON	QU	NT	YT	**Total**
C. americanum	3(3)	11(15)	15(34)	21(72)	15(21)	7(11)			72(156)
C. hookeri									
v. *hookeri*	6(6)	9(14)	10(24)	1(1)	7(15)		3(4)		36(64)
v. *pseudodeclinatum*	2(3)								2(3)
C. ochotense									
v. *ochotense*			1(2)				6(11)		7(13)
v. *alaskanum*								1(1)	1(1)
C. pallasii	4(4)	9(19)	17(33)	3(11)	9(14)	4(5)			46(86)
C. villosum	7(7)	18(39)	28(39)	9(13)	12(23)	3(14)	1(11)		78(146)
Corispermum sp.	6(6)	3(4)	7(7)	4(5)	8(8)		1(1)		29(31)
Total	28(29)	50(91)	78(139)	38(102)	52(81)	14(30)	11(27)	1(1)	272(500)

TABLE 2. Ecozones where Bugseed (*Corispermum* spp.) localities in Canada occur.

	Species # localities						
Ecozone	*C. americanum*	*C. hookeri*	*C. ochotense*	*C. pallasii*	*C. villosum*	*C.* sp.	**Total**
Prairie	42	19		24	45	11	141
Boreal Shield	17	1	1	4	10	3	36
Mixedwood Plains	5	8		6	6	6	31
Boreal Plains	6			8	8	1	23
Montane Cordillera	1	3		3	6	6	19
Taiga Plains		3	6		1	1	11
Pacific Maritime		5		1	1	1	8
Boreal Cordillera	1		1		1		3

and gravel (Mosyakin 1995) (Figure 1). Most specimens (55%) came from natural areas but 30% came from anthropogenically impacted areas; 15% had no habitat description (Table 3). Of the natural areas, the most commonly cited habitat was inland sand dunes and blowouts including the Battle River, Beaver Hill, Buffalo Park, Fish Lake, Edson and Middle Sand Hills of Alberta, the Athabasca, Dundurn, Elbow, Great, Pelican Lake and Seward Sand Hills of Saskatchewan, and the Routledge and Brandon Sand Hills of Manitoba. Lacustrine beaches and dunes along Lakes Huron, Erie and Superior in Ontario, and Lakes Manitoba and Winnipeg in Manitoba were the next most common habitat. Riparian sand banks and dunes along the Mackenzie River in the Northwest Territories, the Laird and Fraser Rivers in British Columbia, the Saskatchewan, Frenchman and Qu'appelle Rivers in Saskatchewan, the Athabasca, Elbow, Red Deer and Saskatchewan rivers in Alberta, and the St. Lawrence River in Quebec are also the location of many Bugseed populations. Sandy roadsides, railways, and other disturbed sandy areas like landfills and parking lots are the most common anthropogenically impacted habitats of bugseeds.

The Alaskan Bugseed (*C. ochotense*) is the northernmost species: var. *ochotense* Ignatov was found along the Mackenzie River Valley of the Northwest Territories and var. *alaskanum* Mosyakin near Kluane Lake in the Yukon. This species also occurs in Alaska and eastern Russia (Mosyakin 1995). Specimens of Alaskan Bugseed that were transitional to Hairy Bugseed in growth form (i.e. taller than those specimens further north) were found on the Athabasca Sand Dunes (Figure 2) in northern Saskatchewan (Welsh et al. 2003).

Hairy Bugseed (*C. villosum*) is the most common and widespread species in Canada occurring as far south as the Great Lakes and as far north as the Mackenzie River Valley in Northwest Territories (Figure 3). Plants of this species occur in sandy habitats in seven provinces/territories across eight different ecozones. Hairy Bugseed is also found in ten northern U.S. states but its distribution is disjunct (NatureServe 2010*); this could be due to the lack of accurate species identifications in regional U.S. herbaria.

American Bugseed (*C. americanum* var. *americanum*) has a similar distribution as Hairy Bugseed although it has not been found in the Northwest Territories, nor as far west as the latter species (Figure 4). However, its eastern limit extends right to the mouth of the St. Lawrence River in Quebec. It was found in six ecozones in southern Canada. American Bugseed

FIGURE 1. Habitat of Hooker's Bugseed, *Corispermum hookeri* var. *hookeri*, on a sand dune in Spruce Woods Provincial Park, Manitoba. Photograph by D. B. Robson.

TABLE 3. Bugseed (*Corispermum* spp.) habitat types at each Canadian locality.

Habitat type	Species # localities						
	C. americanum	*C. hookeri*	*C. ochotense*	*C. pallasii*	*C. villosum*	*C.* sp.	**Total**
Natural areas							
Inland active sand dunes & blowouts	19	11	1	1	10	10	52
Lacustrine beaches & dunes	3	4	3	5	11	3	29
Riparian sand banks & dunes	4	4	1	1	10	1	21
Inland sandy hills & cliffs	5	3		6	5	1	20
Inland sandy plains	3			5	7	1	16
Riparian sandbars	1	4		3	1	2	11
Anthropogenically impacted areas							
Sandy roadsides	8	3	2	3	4	2	22
Railways	3	1		7	9		20
Sandy disturbed areas	9	3	1	3	3	1	20
Sand and gravel pits	5	1			3		9
Cultivated fields	3			1	2	2	8
Sandy fireguards	1			1	1		3
No habitat description	8	5		10	12	6	41

is common in the U.S., extending from Washington south to California and east to Texas, Ohio, Kentucky and Arkansas (NatureServe 2010*).

Pallas Bugseed (*C. pallasii*) is native to Russia, Mongolia and China, and introduced in Europe (Welsh et al. 2003). Its distribution also spans widely across Canada in six ecozones but is less abundant than Hairy and American Bugseed (Figure 5). It has been found only as far north as Bonnyville, Alberta, just west of Cold Lake. In the U.S. Pallas Bugseed has been found only in Michigan, North Dakota and Ohio: it appears to be extirpated in Missouri (NatureServe 2010*).

Hooker's Bugseed is found in six ecozones and six provinces/territories (Figure 6). This species appears to be endemic to Canada as no specimens from the U.S. have been documented yet (NatureServe 2010*). A unique variety of Hooker's Bugseed, var. *pseudodeclinatum* Mosyakin, has been found near Burnaby and in the Okanagan of British Columbia; no other specimens possess seeds that are two times as long as broad

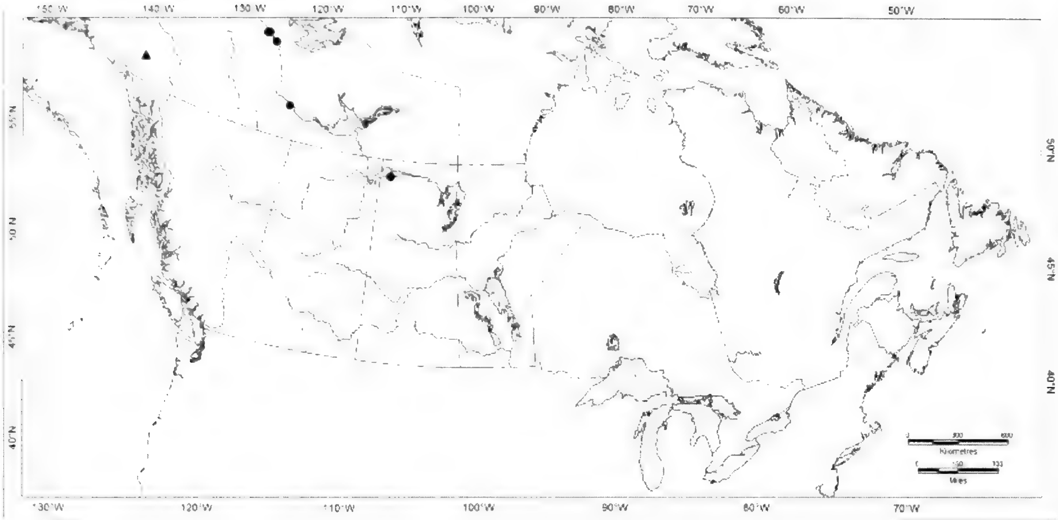


FIGURE 2. Distribution map of Alaskan Bugseed, *Corispermum ochotense* var. *ochotense* (circles) and *C. o.* var. *alaskanum* (triangle), in Canada based on Canadian herbarium specimens.

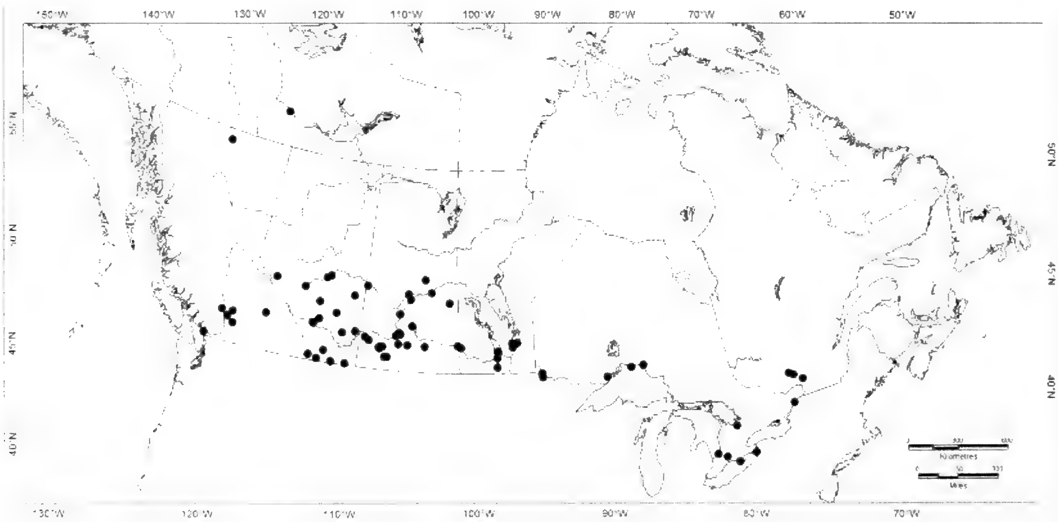


FIGURE 3. Distribution map of Hairy Bugseed, *Corispermum villosum* in Canada based on Canadian herbarium specimens.

(Mosyakin 1995). However this designation is based on only two specimens: the holotype, collected in 1965 from Burnaby Lake and the paratype, collected from Quilchena in 1906. Since no recent specimens of this taxon have been obtained, the validity of this designation is somewhat questionable as the specimens could just represent unusual plants rather than entire populations; additional specimens of Bugseed from these localities are needed to illuminate the issue. Unfortunately, as land use in southwestern B.C. has changed dramatically since the type specimens were collected, the existence of appropriate habitat at present is unknown.

Status of the bugseeds in Canada

The most frequently collected species in Canada is Hairy Bugseed followed closely by American Bugseed. Pallas Bugseed is less common but its status is uncertain as it may be at least partly introduced to North America from Europe (Welsh et al. 2003). Further study of this species is needed to determine whether it is native, exotic or possibly both. In Welsh et al.

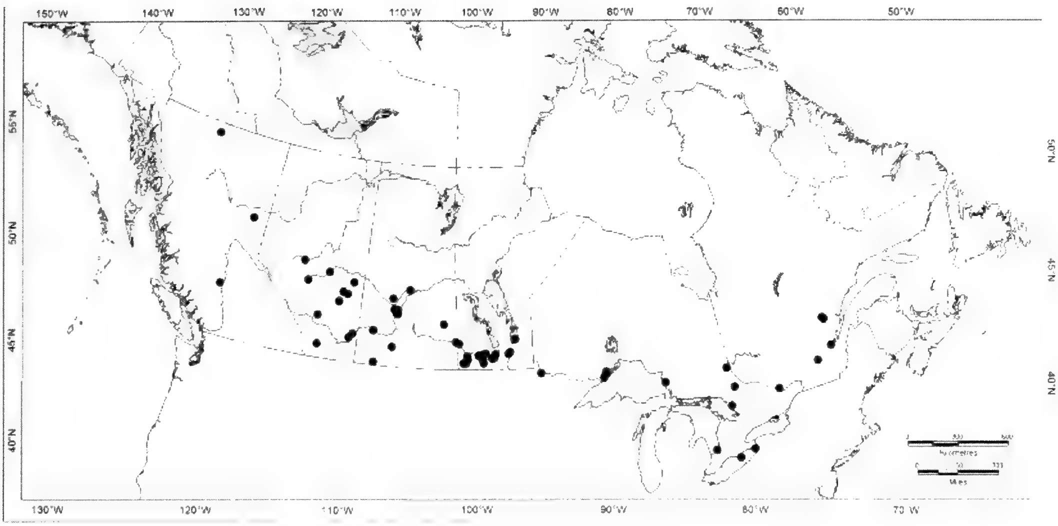


FIGURE 4. Distribution map of American Bugseed, *Corispermum americanum*, in Canada based on Canadian herbarium specimens.

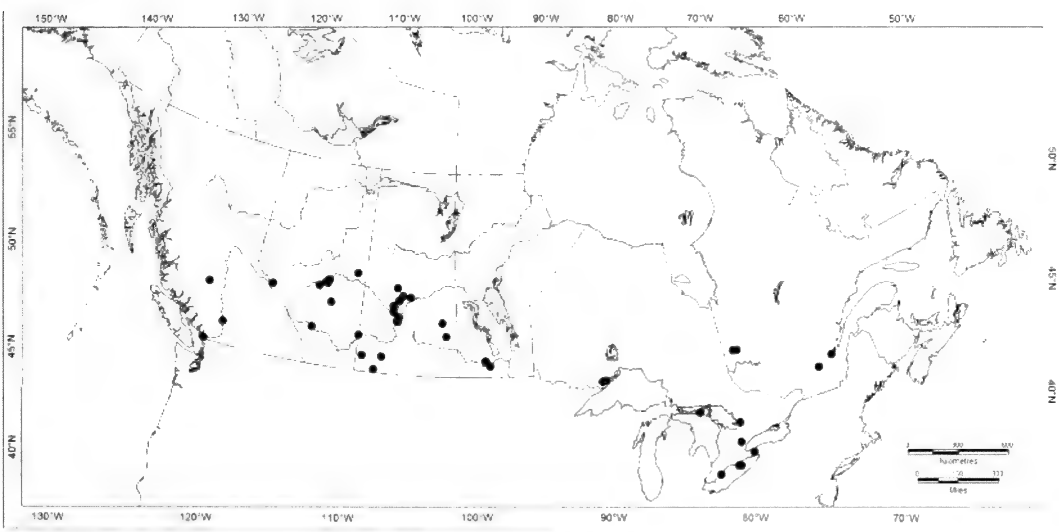


FIGURE 5. Distribution map of Pallas Bugseed, *Corispermum pallasii*, in Canada based on Canadian herbarium specimens.

(2003) it was postulated that Hooker's Bugseed was introduced to Ontario from western Canada. However, the presence of Hooker's Bugseed in natural lacustrine beaches and dunes in the Great Lakes region rather than anthropogenically disturbed ones along roadsides and railways, suggests that it is more likely native to Ontario. Alaskan Bugseed is the rarest species; it has only been found at eight localities in Canada. However, as it occurs in areas that are seldom visited by botanists, it may be more widespread.

None of the Bugseed taxa are currently candidates for Committee on the Status of Endangered Wildlife in Canada (2010*) status. However, most Canadian Bugseed taxa have rare National General Status (CESCC 2005*) and NatureServe ranks (2010*) in the jurisdictions where they occur. Several omissions were identified during the herbarium specimen review: NatureServe (2010*) has not ranked Pallas Bugseed in Alberta, Saskatchewan or Quebec, nor Hairy Bugseed in Alberta, Saskatchewan or Northwest Territories even

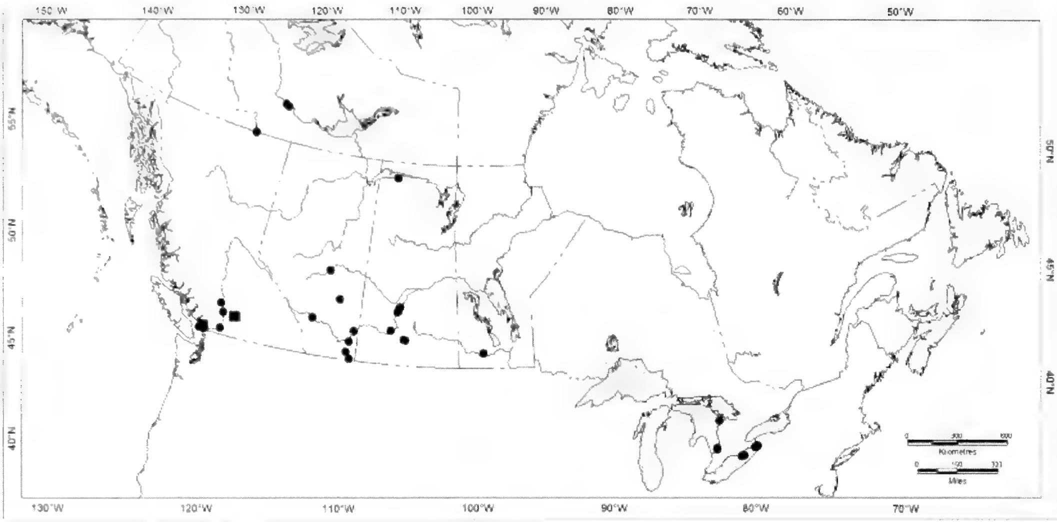


FIGURE 6. Distribution map of Hooker's Bugseed, *Corispermum hookeri* var. *hookeri* (circles) and *C. h.* var. *pseudodeclinatum* (squares), in Canada based on Canadian herbarium specimens.

though their occurrence has been documented in these jurisdictions in various publications (Mosyakin 1995; Cody et al. 2003; Harms 2003; Welsh et al. 2003; Cayoutte and Dalpé 2007). Further, there is no National General Status rank for Pallas Bugseed or Hairy Bugseed in Alberta (2005*). In several other cases taxa have uncertain or undetermined ranks (CESCC 2006*; NatureServe 2010*) due to the lack of data on the species in that jurisdiction. This is understandable since, of the Bugseed herbarium specimens examined, only 27% of them were collected since 1970. To address these inaccuracies suggested ranks for Bugseed taxa in Canada were made (Table 4). One problem in particular is the "Exotic" rank given to American Bugseed in British Columbia (CESCC 2006*). Since all three specimens of American Bugseed found in British Columbia are from remote, natural habitats rather than urban, anthropogenically disturbed areas where species introductions typically occur, this designation is most likely wrong. Thus the recommended rank for American Bugseed in British Columbia is "May Be At Risk" or "Critically Imperilled". The Bugseed populations found in Quebec are a bit of an enigma; although most recent records are from anthropogenically impacted areas, there are a few records of plants on natural riparian sand bars along the St. Lawrence River as far back as 1932. Whether the Bugseed species found in Quebec are indeed "native" to that province or were introduced from farther west is difficult to say without more recent specimen records. Therefore I ranked the Quebec taxa as "Undetermined" or "Uncertain" until additional information is available, rather than "Exotic" as this term implies that the species in native to another country.

Discussion

The broad distribution pattern of Canadian bugseeds suggests that they are less influenced by factors such as temperature, moisture, day length and average autumnal frost dates than by substrate, occurring primarily where there are course-textured bare or moderately disturbed soils present. However, they are likely intolerant of high salinity as no plants were found on oceanic beaches. Although Alaskan Bugseed is restricted to areas north of the 59th parallel in Canada, it also occurs broadly in northern Asia so its distribution is also wide (Mosyakin 1995). There is a certain amount of distributional overlap with two, three and even four Bugseed species being observed in some localities. Whether the niches of the species at these localities overlap completely, or are slightly different is unknown and needs further research. Bugseed species may hybridize with each other in areas of distributional overlap as several of Mosyakin's annotation labels indicated the existence of some intermediate specimens. However, natural interspecific hybridization in annual plants is thought to be relatively rare due to frequent sterility of the seeds (Solbrig 1970), although there are exceptions (Rieseberg 1997). An examination of the genetic profile of Bugseed plants may be useful in determining whether hybrids are currently produced, and whether some North American species arose from hybrid origins.

Plant competition is relatively low in sand dune habitats due to limited resources, recurrent disturbances, and drastic fluctuations in temperature and moisture availability (Perumal and Maun 2006). The adaptations that allow plants to survive under such harsh conditions do not enable them to thrive in habitats that are less stressful, where plant competition is more intense

TABLE 4. Suggested national and subnational NatureServe, 2010* (NS) and Canadian Endangered Species Conservation Council, 2005* (CC) status ranks for Canadian Bugseed (*Corispermum*) taxa based on a herbarium specimen review.

	Proposed Status Ranks[1]																	
	Canada		BC		AB		SK		MB		ON		QU		NT		YT	
Species	NS[2]	CC[3]	NS	CC	NS	CC	NS	CC	NS	CC	NS	CC	NS	CC	NS	CC	NS	CC
C. americanum	3	3	1	2	2	2	3	3	3	3	3	3	U	5	–	–	–	–
C. hookeri	3	3	2	2	2	2	2	2	1	2	2	2	–	–	1	2	–	–
v. *hookeri*	3	3	2	2	2	2	2	2	1	2	2	2	–	–	1	2	–	–
v. *pseudodeclinatum*	1	2	1	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–
C. ochotense	2	2	–	–	–	–	1	2	–	–	–	–	–	–	2	2	1	2
v. *ochotense*	2	2	–	–	–	–	1	2	–	–	–	–	–	–	2	2	–	–
v. *alaskanum*	1	2	–	–	–	–	–		–	–	–	–	–	–	–	–	1	2
C. pallasii	3	3	1	2	2	2	3	3	1	2	2	2	U	5	–	–	–	–
C. villosum	3	3	2	2	3	3	3	3	2	2	2	2	U	5	1	2	–	–

[1] Proposed status using NatureServe, 2010* (NS) and Canadian Endangered Species Conservation Council 2005* (CC) ranks.
[2] Key to NatureServe Status Ranks
1 = Critically Imperilled
2 = Imperilled
3 = Vulnerable
U = Uncertain
[3] Key to Canadian Endangered Species Conservation Council Status Ranks
1 = At Risk (protected by *Species at Risk Act 2002,* or listed by Committee on the Status of Endangered Wildlife in Canada or a provincial governing body)
2 = May Be At Risk
3 = Sensitive
5 = Undetermined

(Grime 2001; Perumal and Maun 2006). A study on the sand dune successional gradient at Lake Michigan dunes recorded the presence of American bugseeds only on the more open foredunes and secondary dunes, not the more heavily vegetated savanna nearby (Leicht-Young et al. 2009). In fact, Bugseed seeds are susceptible to damping off fungi when grown in moister, loamy soils rich in organic matter (Van Asdall and Olmstead 1963); this may explain why bugseeds, despite their annual habit, have not become major agricultural weeds in fertile Canadian croplands.

Mosyakin (1995) postulates that bugseeds likely migrated from Asia into North America along three paleo-migration routes along the Bering Land bridge approximately 38 000 years before present. As the glaciers melted, the barren lands would have been colonized by annual, psammophilic pioneer plants like bugseeds. Since then new species of bugseeds evolved in North America resulting in the present compliment of species. Some psammophilic species are now becoming rare due to the loss of sand dune complexes (Robson 2006). The oscillation of lake levels and impact of severe storms has resulted in the loss and alteration of lacustrine dune habitats (Maun 1989). Dune stabilization has been documented as occurring in the Great Lakes region and the Prairies likely due in part to the suppression of wildfires (Hugenholtz and Wolfe 2005; Catling et al. 2008). Dune stabilization over the last 50 years in the Prairie ecozone where most Bugseed populations are found has resulted in the loss of 50% to 90% of the active sand surface (Hugenholtz and Wolfe 2005; Robson 2006). However, climate models suggest that increasing evapotranspiration in the prairies due to climate change could increase dune activity, especially if there are severe and prolonged droughts (Wolfe and Thorpe 2005). This report provides important historical information for determining the status of these plants as habitats change in the future.

The results of this study show that the status ranks for bugseeds in Canada are in need of revision and status recommendations are made based on the number of historical localities. However, information on whether the population size of and habitat for a taxon is declining is also required for status assessment (NatureServe 2010*). Given the loss of dune habitats and alteration of land use that has occurred in the last several decades, there is a strong need for field studies where these historical populations of bugseeds are revisited to determine if they are still extant and if so, what the population size is. As several other sand dunes species, including Smooth Goosefoot (*Chenopodium subglabrum* (S. Wats.) A. Nels.), Hairy Prairie Clover (*Dalea villosa* (Nutt.) Spreng. var. *villosa*), Small-flowered Sand-verbena (*Tripterocalyx micranthus* (Torr.) Hook.), Tiny Cryptanthe (*Cryptantha minima* Rydb.) and Western Spiderwort (*Tradescantia occidentalis* (Britt.) Smyth are already protected under the *Species at Risk Act 2002* due to the documented decline in sand dune habitat, bugseeds are likely threatened by similar factors. The main difference between the already listed rare dune plants and bugseeds is that

the former mainly grow on inland or riparian dunes in the prairies while the latter are also capable of growing in lacustrine dunes and some anthropogenically disturbed sites. However, records of bugseeds that were found on anthropogenically disturbed sites were often several decades old. As exotic plant species have come to dominate anthropogenically disturbed sites, native ruderals may not be as common in these areas as before. Once again revisitation to historical localities is needed to determine current status. A complicating factor is that since annual psammophilic species typically experience population fluctuations (Li et al. 2005; Robson 2006) multiple visits may be required to determine the presence or absence of these taxa. Taxa most in need of assessment include the Canadian endemic Hooker's Bugseed and the northern Alaskan Bugseed. Collecting further information on these taxa will help scientists determine if any are in need of protection under the *Species at Risk Act 2002*.

Acknowledgments

Financial support for this research was received from The Manitoba Museum Foundation Inc. Thanks are extended to Jacques Cayouette at the Agriculture & Agri-Food Canada Vascular Plant Herbarium for sending me his information on *Corispermum* in Quebec. Vernon Harms graciously reviewed an earlier version of this manuscript. Collections at the following herbaria were examined: University of British Columbia (UBC), Royal British Columbia Museum (V), University of Alberta (ALTA), University of Calgary (UAC), Royal Alberta Museum (RAB), University of Regina (USAS), University of Saskatchewan (SASK), University of Manitoba (WIN), The Manitoba Museum (MMMN), Royal Ontario Museum (ROM), University of Guelph (OAC), University of Western Ontario (UWO), University of Waterloo (WAT), University of Toronto (TRTE), Agriculture & Agri-Food Canada Vascular Plant Herbarium (DAO), Canadian Museum of Nature (CAN), University of Montreal (MT), McGill University (MTMG), University of Laval (QFA) and the Government of Quebec (QUE).

Documents Cited (marked * in text)

Canadian Endangered Species Conservation Council (CESCC). 2006. Wild Species 2005: The General Status of Species in Canada. Available at: http://www.wildspecies.ca/wildspecies2005/GS2005_site_e.pdf (accessed October 2010).

Committee on the Status of Endangered Wildlife in Canada (COSEWIC). 2010. Candidate Wildlife Species. Canadian Wildlife Service, Environment Canada, Ottawa. Available http://www.cosewic.gc.ca/eng/sct3/index_e.cfm (accessed October 2010).

NatureServe. 2010. NatureServe Explorer: An online encyclopedia of life [web application]. Version 6.0. NatureServe, Arlington, Virginia. Available http://www.natureserve.org/explorer (accessed September 2010).

Government of Canada. 2002. *Species at Risk Act 2002* Bill C-5, an act respecting the protection of wildlife species at risk in Canada. Available http://www.parl.gc.ca/37/2/parlbus/chambus/house/bills/government/C-5/C-54/C-5TOCE.html (accessed October 2010).

Literature Cited

Betancourt, J. L., A. Long, D. J. Donahue, A. J. Jull, and **T. H. Zabel.** 1984. Pre-Columbian age for North American *Corispermum* L (Chenopodiaceae) confirmed by accelerator radiocarbon dating. Nature 311: 653-655.

Catling, P. M., H. Goulet, and **B. Kostiuk.** 2008. Decline of two open Champlain sea dune systems in eastern Ontario and their characteristic and restricted plants and insects. Canadian Field-Naturalist 122: 99-117.

Cayouette, J., and **Y. Dalpé.** 2007. Découverte de quatre espèces d'intérêt en Mauricie. Flora Quebeca 12: 9-11.

Cody, W. J., K. L. Reading, and **J. M. Line.** 2003. Additions and range extensions to the vascular plant flora of the continental Northwest Territories and Nunavut, Canada II. Canadian Field-Naturalist 117: 448-465.

Grime, J. P. 2001. Plant strategies, vegetation processes, and ecosystem properties, 2nd edition. John Wiley & Sons, Rexdale.

Harms, V. L. 2003. Checklist of the vascular plants of Saskatchewan and the provincially and nationally rare native plants in Saskatchewan. University Extension Press, Saskatoon.

Hugenholtz, C. H., and **S. A. Wolfe.** 2005. Recent stabilization of active sand dunes on the Canadian prairie and relation to recent climate variations. Geomorphology 68: 131-147.

Leicht-Young, S. A., N. B. Pavlovic, R. Grundel, and **K. J. Frohnapple.** 2009. A comparison of seed banks across a sand dune successional gradient at Lake Michigan dunes (Indiana, USA) Plant Ecology 202: 299-308.

Li, F.-R., L.-Y. Zhao, X.-Y. Zhao, T.-H. Zhang, and **G. Li.** 2005. The relative importance of pre- and post-germination determinants for recruitment of an annual plant community on moving sandy land. Annals of Botany 96: 1215-1223.

Looman, J., and **K. F. Best.** 1979. Budd's flora of the Canadian Prairie Provinces. Canadian Government Publishing Centre, Supply and Services Canada, Hull.

Maihle, N. J., and **W. H. Blackwell, Jr.** 1978. A synopsis of North American *Corispermum* (Chenopodiaceae). Sida 7: 382-391.

Marshall, I. B., and **P. H. Schut.** 1999. A national ecological framework for Canada. Ecosystems Science Directorate, Environment Canada and Research Branch, Agriculture and Agri-food Canada, Ottawa, Ontario.

Matthews, J. V., C. E. Schweger, and **O. L. Hughes.** 1990. Plant and insect fossils from the May Indian village section (central Yukon): new data on middle Wisconsinan environments and glaciation. Geographie physique et Quaternaire 44: 15-26.

Maun, M. A. 1989. Population biology of *Ammophila breviligulata* and *Calamovilfa longifolia* on Lake Huron sand dunes. III. Dynamic changes in plant community structure. Canadian Journal of Botany 67: 1267-1270.

Moss, E. H. 1983. Flora of Alberta (2nd edition by J. G. Packer). University of Toronto Press, Toronto.

Mosyakin, S. L. 1995. New taxa of *Corispermum* L. (Chenopodiaceae), with preliminary comments on the taxonomy of the genus in North America. Novon 5: 340-353.

Perumal, V. J. and **M. A. Maun.** 2006. Ecopysiological response of dune species to experimental burial under field and controlled conditions. Plant Ecology 184: 89-104.

Rieseberg, L. H. 1997. Hybrid origins of plant species. Annual Review of Ecology and Systematics 28: 359-389.

Robson, D. B. 2006. A conservation evaluation of smooth goosefoot, *Chenopodium subglabrum* (Chenopodiaceae), in Canada. Canadian Field Naturalist 120: 335-341.

Scoggan, H. J. 1956. Flora of Manitoba. National Museum of Canada, Ottawa.

Scoggan, H. J. 1978. The Flora of Canada. National Museum of Canada, Ottawa.

Solbrig, O. T. 1970. Principles and methods of plant biosystematics. The Macmillan Company, Toronto.

Sukhorukov, A. P. 2007. Fruit anatomy and its taxonomic significance in *Corispermum* (Corispermoideae, Chenopodiaceae). Willdenowia 37: 63-87.

Van Asdall, W., and **C. E. Olmstead.** 1963. *Corispermum hyssopifolium* on the Lake Michigan dunes it community and physiological ecology. Botanical Gazette 124: 155-172.

Welsh, S. L., C. W. Crompton, and **S. E. Clemants.** 2003. Chenopodiaceae. Pages 258-404 *in* Flora of North America, volume 4, Magnoliophyta: Caryophyllidae, part 1. *Edited by* Flora of North America Editorial Committee. Oxford University Press, New York.

Wolfe, S., and **J. Thorpe.** 2005. Shifting sands: climate change impacts on sand hills in the Canadian prairie and implications for land use management. Prairie Forum 30: 123-142.

Received 12 October 2010
Accepted 29 October 2010

Notes

Double-litters in Coywolf, *Canis latrans* × *lycaon,* Packs Following the Death or Disappearance of a Resident Territorial Male

JONATHAN G. WAY

Eastern Coyote Research, 89 Ebenezer Road, Osterville Massachusetts 02655 USA; e-mail: jw9802@yahoo.com.

Way, Jonathan G. 2010. Double-litters in Coywolf, *Canis latrans* × *lycaon,* packs following the death or disappearance of a resident territorial male. Canadian Field-Naturalist 124(3): 256–257.

Previous research on my Cape Cod, Massachusetts study site documented the killing of a breeding male Coywolf (*Canis latrans* x *lycaon*; also called Eastern Coyote) and a subsequent increase in local pack density one year later. This study documents double-litters produced in two packs following the death or disappearance of the original breeding male.

Key Words: Coywolf, Eastern Coyote, *Canis latrans* × *lycaon*, breeding male, double litter, multiple litters, reproduction.

Previous research showed that the death of a breeding male Coywolf (*Canis latrans* × *lycaon*; also called Eastern Coyote: Way et al. 2010) caused a doubling of pack density, likely due to the lack of that male guarding the original territory and a subsequent influx of young animals into that territory (Way et al. 2009). Here, I report instances of multiple females producing litters (hereafter double-litter) within the same territory when the original breeding male died or disappeared on Cape Cod, Massachusetts. While other studies have documented double-litters in Coyotes (*Canis latrans*) and Wolves (*Canis lupus*) (Way et al. 2001; Mech and Boitani 2003; and sources within both), this study is unique because it provides evidence that they happened directly after the turnover of resident breeding males.

During 1999-2000, a 13.4 kg radio-collared female Coywolf (ID #9902) was tracked and regularly observed with an uncollared but recognizable mate (based on physical characteristics: robust build, light grayish-brown coat with thin white shoulder stripes). Their rendezvous site (see Way et al. 2001) during June 2000 was on a golf course where I often (5 days a week) observed the pair, 2-3 full-grown (probable) yearling helpers, and 5-6 pups of the year (10 total). During these observations, a 21.5 kg transient radio-collared male (#0001) spent much time in and at the edge of 9902's (Hyannisport Pack) territory. Field work was not conducted from late June 2000 until early January 2001 but when research on this pack resumed, 9902's mate had disappeared and 0001 was paired with 9902. That spring (2001), 0001 tended two dens 2.8 km apart within the pack's territory: 9902's and likely one of her daughters (Way et al. 2001). Five pups were determined by residents and the author (and 0001 was sighted 5 times and often radio-located) at the auxiliary den and I observed ≥2-3 newborn pups with 9902 in a den mid-March that 0001 also attended. Coywolf 9902 tended these pups separately from the auxiliary den until late summer 2001 when she was displaced from the territory, likely by that daughter. She left the territory and was ultimately shot ca. 10 km away in November 2002. Coywolf 0001 was hit and killed by a car on 20 August 2001 and radio-contact with this pack was lost. The fates of both litters were unknown following the disappearance of 9902 and death of 0001 in summer 2001. However, a ~6 year old, 18 kg lactating female (#0606) was captured in this area and radio-tracked from June 2006 – February 2008 until either her collar died or she left the study area. This gray animal looked exactly like 9902's daughter from 2001 (J. Way, unpublished data), was of the appropriate age, and genetics confirmed that she was one of 9902's offspring (Way et al. 2010, B. White, Trent University, unpublished data). It is possible that 0606 was able to displace her mother in 2001 because of her larger body size and the likelihood that neither was related to 0001.

In a second scenario, a 17.3 kg radio-collared breeding male Coywolf (#0601) was captured March 2006. He and his uncollared mate had ≥3-4 pups that I directly observed during summer 2006. One of their 7-month old daughters (14.6 kg, #0608) was captured 11 November 2006 and tracked with 0601 until December 2006 when he was shot and killed. Subsequently, 0608 never dispersed from her natal range. She acted as a helper in 2007 to an observed five pups of her putative mother whom I identified based on physical characteristics and behavior when 0601 was alive: she was dominant over 0608 but neutral and paired with 0601. In addition, in 2007 I observed

a new tall, brown uncollared adult breeding male. In 2007-2008, I observed (n = 4) 0608 scent-marking portions of the original territory with one or two other individuals (three observations included that new male) and gave birth in April 2008 to a litter while a second Coywolf believed to be her mother was observed lactating and interacting with 0608 within the core of that territory. I never was able to directly determine a pup count of either litter that summer but was certain that 0608 had pups (≥ 3-4) based on: (1) vocalizations (e.g., whimpering, whining) that I heard in mid-May in a swamp on the Fairgrounds Golf Course in Marstons Mills, (2) visual observations (n = 8) of her lactating in spring and early summer 2008, and (3) her four week localization in the Fairgrounds swamp. In May and June 2008, I also heard pups howling from the area where 0608 was born in 2006 (determined by repeated locations of 0601 at that site from April - May 2006) at the Northeast edge of Mystic Lake. This den was 1.2 km away from 0608's golf course den and both were in the core of 0608's (and formerly 0601's) territory. In addition, I observed 0608s putative mother crossing a main road (Race Lane) three times in April – May 2008 traveling back to the Mystic Lake probable den site. The study ended in early March 2009 when 0608 suspiciously disappeared; her collar was found in late-October 2009 at a residence ca. 5 km to the west.

Unfortunately less was known about the circumstances of these double-litter events than the detail reported in Way et al. (2009), mainly because fewer animals were concurrently radio-collared in these packs. Ultimately, I never made a maximal direct count of both of the double-litters in both packs. But based on available data provided herein, both new males (0001 and tall, brown adult) in the respective packs appeared to have mated with two females in each territory. There is the potential that another male mated ≥1 of the females in each pack (e.g., I observed an uncollared distinct looking white-faced, tan male that traveled alone within 0608s territory [≥ 4 residents in the pack] in February 2008) but the point of this paper is to document double litters following the disappearance of the original male and that possibility would not distract from the findings herein. And the fact that the new males were not resident in those territories until the original males disappeared raises the possibility that the disappearance of the original breeding males allowed the unrelated males to join the resident pack and breed more than one female because they both were probably not related to either female in the respective packs. Circumstances prevented my verifying litter survival in these packs, increase in density of either pack, increase in transients (i.e., dispersal of the pups), or decrease in territory size (Way et al. 2009), which distracts from these findings. However, I did document four adults/yearlings (i.e., a normal pack size) in both groups during winter. Therefore, the possibility remains that most pups in the double litters died or dispersed in their first autumn.

Despite not documenting litter survival or increase in local Coywolf density, it is nonetheless noteworthy that two double-litters were documented following the turnover of breeding males. This indicates the potential for densities of Coyotes/Coywolves to increase following loss of breeding males (Way et al. 2009).

Acknowledgments

I thank the following Coywolves for making this study possible: Mizz (ID #9902), Glope (#0001), Raider (#0606), Mystic (#0601), and Mup (#0608). In addition, two anonymous reviewers provided valuable feedback.

Literature Cited

Mech, L. D., and **L. Boitani.** *Editors.* 2003. Wolves: behavior, ecology, and conservation. University of Chicago Press, Chicago, Illinois. 448 pages.

Way, J. G, P. J. Auger, I. M. Ortega, and **E. G. Strauss.** 2001. Eastern coyote denning behavior in an anthropogenic environment. Northeast Wildlife 56: 18-30.

Way, J. G., B. C. Timm, and **E. G. Strauss.** 2009. Coywolf, *Canis latrans* × *lycaon,* pack density doubles following the death of a resident territorial male. Canadian Field-Naturalist 123: 199–205.

Way, J. G., L. Rutledge, T. Wheeldon, and **B. N. White.** 2010. Genetic characterization of Eastern "Coyotes" in eastern Massachusetts. Northeastern Naturalist. 17: 189–204.

Received 9 April 2010
Accepted 15 May 2010

Proportion of Calves and Adult Muskoxen, *Ovibos moschatus* Killed by Gray Wolves, *Canis lupus*, in July on Ellesmere Island

L. DAVID MECH

U.S. Geological Survey, Northern Prairie Wildlife Research Center, 8711 – 37th St. SE, Jamestown, North Dakota 58401-7317 USA

Mailing address: The Raptor Center, 1920 Fitch Avenue, University of Minnesota, St. Paul, Minnesota 55108 USA; e-mail: david_mech@usgs.gov or mechx002@umn.edu

Mech, L. David. 2010. Proportion of calves and adult Muskoxen, *Ovibos moschatus* killed by Gray Wolves, *Canis lupus*, in July on Ellesmere Island. Canadian Field-Naturalist 124(3): 258–260.

Generally Gray Wolves (*Canis lupus* L., 1758) tend to focus predation on young-of-the-year ungulates during summer, and I hypothesized that wolves preying on Muskoxen (*Ovibos moschatus* Zimmerman, 1780) in summer would follow that trend. Over 23 July periods observing wolves on Ellesmere Island, Nunavut, Canada, I found that packs of 2-12 adult wolves killed seven calves, one yearling, and five adult muskoxen at distances of 2.9 to 32 km from their current dens and pups. Given a possible bias against finding calves because of their fewer remains, these results do not necessarily refute the hypothesis, but they do make it clear that adult muskoxen form an important part of the wolves' diet in July and thus possibly at other times during summer.

Key Words: Gray Wolves, *Canis lupus*, Muskox, *Ovibos moschatus*, nutrition, predation, predator-prey relations, arctic.

Wolf (*Canis lupus* L., 1758) predation on ungulates during summer tends to focus on young-of-the-year. This generalization is well documented for White-tailed Deer (*Odocoileus virginianus* Zimmerman, 1780), Moose (*Alces alces* L., 1758), and Caribou (*Rangifer tarandus* L., 1758) (summarized by Peterson and Ciucci 2003), Bison (*Bison bison* L., 1758) (Carbyn et al. 1993), and Elk (*Cervus elaphus* L., 1758) (Smith and Bangs 2009). Thus it is reasonable to hypothesize that this generalization would apply to wolf predation on Muskoxen (*Ovibos moschatus* Zimmerman, 1780) during summer. One of the earliest publications on the subject supported that hypothesis, based on documenting four Muskox calf kills (Mech 1988). It also seems reasonable to hypothesize that if wolf packs did kill any adult Muskoxen in summer, it would be larger packs of wolves that did so. I tested both these hypotheses during 23 summers of observing wolf packs in Canada's High Arctic.

I studied wolves and their primary prey, Muskoxen, in the Eureka area of Ellesmere Island (80°N, 86°W), Nunavut, Canada during July each year from 1986 through 2009. The study area included primarily the region of the Fosheim Peninsula in a 180° arc north of Eureka, from Eureka Sound to Remus Creek, and from Slidre Fiord to Canon Fiord, although in 2009, I obtained some data from along the south shore of Slidre Fiord. The study area included shoreline, hills, lowlands, creek bottoms, and the west side of Blacktop Ridge. Wolves, Muskoxen, and Arctic Hares (*Lepus arcticus* Ross, 1819) have long been common in the area (Tener 1954), and wolves have denned there for decades or even centuries (Parmelee 1964, Grace 1976, Mech and Packard 1990). From at least 1986 through 1997, a pack of three to seven adult wolves that at times occupied an area of at least 2600 km^2 preyed on Muskoxen and Arctic Hares and produced pups almost annually in traditional dens in the area (Mech 1995). In 1997 and 2000, however, after snow in mid August abnormally covered the area for the rest of the year, muskox and hare numbers crashed, and wolves disappeared (Mech 2000). After a few years of normal weather, both prey species began to recover; wolves reappeared in 2003 and then began reproducing in 2004 (Mech 2005) and continued to reproduce each year through 2009. During the latter period, packs of up to 12 adults were observed.

During two to four weeks in July of each year (except 1999), associates and I attempted to locate a pack of denning wolves in the study area by experience, tracking, and following nursing females. When possible we observed these animals from all terrain vehicles (ATVs) close-up around the den, followed them on ATVs while they hunted, and observed them from long distances through binoculars and spotting scopes (Mech 1988). The amount of time spent following the wolves on ATVs was greater from 1986 through 1998, so the sample is biased toward those years. In 2009, we radio-tagged a breeding male with a combination VHF/GPS/Argos satellite collar and radio-tracked the animal and his pack from the ground (Mech and Cluff 2010). We noted the age classes of the muskoxen they killed during these observations.

During the 23 July study periods, two wolf packs of 2 to at least 12 adults (non-pups) occupying the study area consecutively were documented killing seven

calves, one yearling, and five adult Muskoxen (Table 1). There was no relationship between pack size or hunting-pack size (traveling-pack size) and whether the kill was a calf or adult. Wolves killed Muskoxen from 2.9 to 32.0 km straight-line distance from their current dens and pups. Two of the adult kills were made on a river bed, one was along the shore of a fiord at the base of a 6.1 km-long hill, and one within 200 m of the shore at the base of the same hill. The fifth adult was attacked on a hillside (Mech and Adams 1999). The calves and yearling were killed on level tundra, except one the wolves chased up a hill, after the wolves had killed two others a few minutes earlier (Mech 1988). One calf and a yearling were killed during a single attack.

Little was known about wolf predation on muskoxen during summer except for anecdotal accounts (Mech 1988, Mech and Adams 1999), but based on knowledge of summer predation by wolves on other large ungulates, a logical hypothesis was that wolves would prey primarily on Muskox calves during summer. The present long-term assessment, however, does not support that hypothesis. My data indicate that wolves kill both calves and adults during summer, at least during July, possibly in about equal proportions. This conclusion could be biased against proportion of calves, however, because wolves would spend less time at calf kills, and their sparse remains would be harder to find. This would have been especially relevant to my 2009 observations which were made from about 7 km away through 12-45× binoculars and scope. However, at other times I observed nine of the kills (seven calves, one yearling, and one adult) while following the wolves, so there should have been no bias in proportion of each age killed in this subsample. My results seem contrary to most other studies of wolves preying on ungulates in summer. However in most other study areas it has not been possible to quantify the ratio of adults to young-of-the-year taken. In the one study that has been able to, juvenile Moose comprised 90% of the individuals taken, although that study may also have been biased against finding calves (Sand et al. 2008). Given the possible bias in my results also, I cannot consider my hypothesis supported. What is clear from my data, however, is that adult Muskoxen do contribute considerably to the wolves' diet in July, and given their much larger size might contribute at least as much biomass as do calves.

TABLE 1. Known Muskoxen killed by wolves during July in the Eureka area, Ellesmere Island, Nunavut, Canada, 1986-2009.

Year	Age	Sex	Number of adult wolves (Number involved in kill)	Km from den
1986[1]	3 calves		7 (7)	3.8–4.4
1987[1]	1 calf		7 (7)	32.0
1989	1 calf, 1 yearling		8 (6)	12.5
1989	1 calf		8 (6)	15.0
1990	1 calf		3 (?)	12.0
1992	1 adult	M	2 (2)	2.9
1994[2]	1 adult	F	4 (1–2)	2.9
1998[3]	1 adult	F	2 (2)	–[4]
2009	1 adult	–	≥12 (?)	10.6
2009	1 adult	–	≥12 (?)	10.6

[1] Mech 1988
[2] Well worn teeth; female marrow was fat
[3] Mech and Adams 1999
[4] Wolves did not den in 1998

Acknowledgments

This study was supported by the U.S. Geological Survey, Environment Canada and the Polar Continental Shelf Project (PCSP) provided logistical support for which I am also grateful, and the Department of Environment, Nunavut issued the research permit. I also thank several colleagues for assisting with the fieldwork, and L. G. Adams, D. R. MacNulty, and C. Darimont for critiquing the manuscript and offering helpful suggestions for improving it. This is PCSP paper 04009.

Literature Cited

Carbyn, L. N., S. M. Oosenbrug, and **D. W. Anions.** 1993. Wolves, bison and the dynamics related to the Peace Athabaska Delta in Canada's Wood Buffalo National Park. Circumpolar Research Series Number 4. Canadian Circumpolar Institute. University of Alberta, Edmonton, Alberta, Canada.

Grace, E. S. 1976. Interactions between men and wolves at an arctic outpost on Ellesmere Island. Canadian Field-Naturalist 90: 149-156.

Mech, L. D. 1988. The Arctic Wolf: Living with the Pack. Voyageur Press, Stillwater, Minnesota.

Mech, L. D. 1995. A ten-year history of the demography and productivity of an arctic wolf pack. Arctic 48: 329-332.

Mech, L. D. 2000. Lack of reproduction in musk oxen and arctic hares caused by early winter? Arctic 53(1): 69-71.

Mech, L. D. 2005. Decline and recovery of a High Arctic wolf-prey system. Arctic 58: 305-307.

Mech, L. D., and **L. G. Adams.** 1999. Killing of a Muskox, *Ovibos moschatus*, by two wolves, *Canis lupus,* and subsequent caching. Canadian Field-Naturalist 113(4): 673-675.

Mech, L. D., and **H. D. Cluff.** 2010. Prolonged intensive dominance behavior between Gray Wolves, *Canis lupus*. Canadian Field-Naturalist 124(3): 215–218.

Mech, L. D., and **J. M. Packard.** 1990. Possible use of wolf (*Canis lupus*) den over several centuries. Canadian Field-Naturalist 104: 484-485.

Parmelee, D. F. 1964. Myth of the wolf. Beaver 295: 4-9.

Peterson, R. O., and **P. Ciucci.** 2003. The wolf as a carnivore. Pages 104-130 *in* Wolves: behavior, ecology, and

conservation. *Edited by* L. D. Mech and L. Boitani. University of Chicago Press, Chicago, Illinois.

Sand, H., P. Wabakken, B. Zimmermann, O. Johansson, H. C. Pedersen, and **O. Liberg.** 2008. Summer kill rates and predation pattern in a wolf-moose system: can we rely on winter estimates? Oecologia 156: 53-64.

Smith, D. W., and **E. E. Bangs.** 2009. Reintroduction of wolves to Yellowstone National Park: History, values and ecosystem restoration. Pages 92-125 *in* Reintroduction of top-order predators, 1st edition. *Edited by* M. W. Hayward and M. J. Somers. Blackwell Publishing.

Tener, J. S. 1954. A preliminary study of the musk-oxen of Fosheim Peninsula, Ellesmere Island, NWT. Canadian Wildlife Services Wildlife Management Bulletin, Series 1, Number 9.

Received 14 May 2010
Accepted 20 October 2010

Photographic Evidence of Bobcats, *Lynx rufus*, in the Kananaskis Valley in Southwestern Alberta

NIKHIL LOBO[1] and JOHN S. MILLAR

Department of Biology, University of Western Ontario, London, Ontario N6A 5B7 Canada
[1] Corresponding author e-mail: Nikhil Lobo <nlobo3@uwo.ca>

Lobo, Nikhil, and John S. Millar. 2010. Photographic evidence of Bobcats, *Lynx rufus*, in the Kananaskis Valley in southwestern Alberta. Canadian Field-Naturalist 124(3): 260–262.

During a study on the foraging behaviour of small mammals in the Kananaskis Valley, Alberta, in August 2009, we obtained video evidence of the presence of a Bobcat (*Lynx rufus*). This is the first confirmed Bobcat sighting in this region of southwestern Alberta.

Key Words: Bobcat, *Lynx rufus*, distribution, Kananaskis Valley, Alberta.

The distribution of the Bobcat (*Lynx rufus*) in Alberta is uncertain. They are believed to be present in very low numbers compared to the other native Alberta cats, the Cougar (*Puma concolor*) and the Canadian Lynx (*Lynx canadensis*) (Soper 1964; Pattie and Fisher 1999). Although Bobcats are active year-round, evidence of their presence is rare because they mostly move about at night, and are extremely shy and secretive (Soper 1964; Hansen 2007). Confirmed records (both sightings and specimens) of their presence in Alberta are scarce (Rand 1948; Soper 1964; Smith 1993). This has led to vague estimates of their distribution.

Using documented occurrences, Smith (1993) estimated the Bobcat's distribution in Alberta as being in the grasslands south of Cypress Hills, west along the Milk River drainage basin, and north along the foothills of the Rocky Mountains (Figure 1). However, Woelfl and Woelfl (1994) found evidence of their presence along the shoreline of the South Saskatchewan River on Canadian Forces Base Suffield (50°32'N, 110°32'E), well north of this described distribution (Figure 1). They are also believed to be found in the eastern portion of the Red Deer River valley (Soper 1964; Banfield 1974).

During a study on the foraging behaviour of small mammals in the Kananaskis Valley in southwestern Alberta, we obtained video evidence of the presence of a Bobcat. In the summer of 2009, infrared cameras (Sony DCR-SR65, Sony of Canada Ltd., Toronto, Ontario) were set up to monitor rodent activity at feeding trays in a coniferous forest stand just off Highway 68 (51°03.08'N, 114°57.55'W; see Figure 1 for location). On August 10, 2009 at 1:50am MDT, one of our cameras recorded the limbs and feet of a large cat walking past it (Figure 2). The combination of the length of the hind foot (approximately 14.6 cm) (Rand 1948; Larivière and Walton 1997), dark spots on the limbs (Rand 1948; Soper 1964; Hansen 2007), and direct register gait (Hansen 2007) indicated that the animal was a Bobcat, as opposed to the other Alberta cats. Lynx can have light grey spots on their limbs, but the length of their hind feet range from 21.0 cm to 25.0 cm, and they have a straddle/overstep gait while walking (Tumlinson 1987; Elbroch 2003). Cougar cubs, but not adults, possess spotted fur, but they also do not have a direct register gait while walking, and the size of the hind foot we observed was too large for a cub (Elbroch 2003; Shaw et al. 2007). Lynx and Cougars have shown a direct register gait only when walking in snow (Elbroch 2003), but it had not snowed for almost two and a half months prior to our sighting.

Our study area was composed of thin stands of mature white spruce forest, mossy ground-cover, and nearby talus slopes. These features are ideal for Bobcats, who prefer to avoid dense forests (Rand 1948; Soper 1964; Smith 1993; Pattie and Fisher 1999). However, Bobcat sightings are rare in this area. One of the co-authors of this paper (J.S.M.) has seen Bobcats only a few times in more than 30 years working in the area, and only much further south, past Highwood Pass (50°36.10'N, 114°58.56'W). Alexander and Gailus (2005) reported finding Bobcat snow-tracks along the Trans-Canada Highway west of Banff, approximately

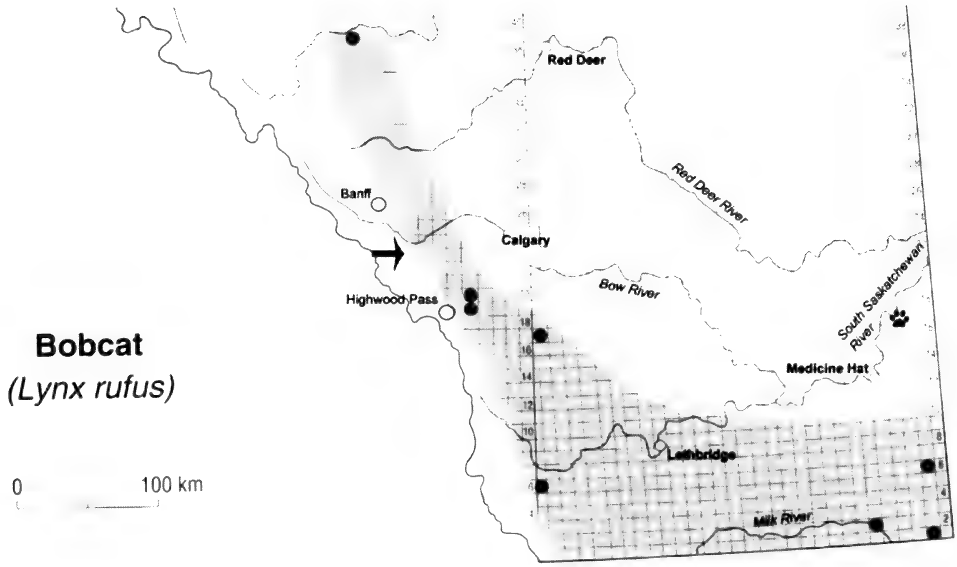


FIGURE 1. Reported distribution (shaded area) of the Bobcat in southern Alberta, from Smith (1993). Numbers displayed on the Alberta-Saskatchewan border (fourth meridian, 110°W longitude) and vertically through Calgary (fifth meridian, 114°W longitude) represent east-west township lines. Closed circles represent confirmed reports of Bobcats (Smith 1993). The paw print indicates the location of Bobcat tracks found at Canadian Forces Base Suffield (Woelfl and Woelfl 1994). The arrow indicates the location of our sighting.

FIGURE 2. Snapshot from the video footage of the front limb of a Bobcat, recorded on 10 August 2009 at 1:50am

60 km northwest of our sighting. Research staff at the nearby University of Calgary Biogeoscience Institute and wildlife biologists at the local Fish and Wildlife Division of Alberta Sustainable Resource Development (Canmore, Alberta) have received only a few unconfirmed sightings in the past 10 years (J. Buchanan-Mappin, personal communication; J. Jorgenson, personal communication). It became mandatory as of 2007 to report all Bobcat pelts harvested in Alberta to Sustainable Resource Development (Edmonton, Alberta), but zero have been registered from the Kananaskis Valley (R. Corrigan, personal communication). Prior to 2007, provincial fur harvest records from Registered Fur Management Areas within the Kananaskis Valley show that one Bobcat pelt was reported in 1992; however, these records are considered unreliable, and a large number of the Bobcat pelts reported in the province prior to 2007 were most likely Lynx (R. Corrigan, personal communication). While reported distributions estimate that Bobcats might be found along the foothills of the Rocky Mountains (Smith 1993), to our knowledge, this is the first confirmed, photographic evidence of a Bobcat present in this region of the Kananaskis Valley. The distribution of this elusive species likely extends further into the Rocky Mountains than previously thought.

Acknowledgments

We thank the staff at the Biogeoscience Institute of the Canadian Rockies and Foothills (University of Calgary), especially J. Buchanan-Mappin for her comments. We also thank J. Jorgenson (Fish & Wildlife Division, Canmore, Alberta) and R. Corrigan (Wildlife Management Branch, Edmonton, Alberta) at Alberta Sustainable Resource Development for their comments, and the Royal Alberta Museum for granting us permission to reproduce their published Bobcat distribution map. We are grateful to C. T. Harding, C. Ibbotson, and R. C. White for their assistance in the field. Comments by three anonymous reviewers greatly improved an earlier version of the manuscript. The original study was funded by grants to J.S.M. from the Natural Sciences and Engineering Research Council of Canada.

Literature Cited

Alexander, S., and **J. Gailus.** 2005. A GIS-Based Approach to Restoring Connectivity Across Banff's Trans-Canada Highway (Technical Report #4). Yukon to Yellowstone Conservation Initiative, Canmore, Alberta. 45 pages.

Banfield, A. W. F. 1974. The mammals of Canada. University of Toronto Press, Toronto, Ontario. 438 pages.

Elbroch, M. 2003. Mammal Tracks & Sign: A Guide to North American Species. Stackpole Books, Mechanicsburg, Pennsylvania. 779 pages.

Hansen, K. 2007. Bobcat: Master of Survival. Oxford University Press, New York, New York. 248 pages.

Lariviere, S., and **L. R. Watson.** 1997. *Lynx rufus*. Mammalian Species 563: 1-8.

Pattie, D., and **C. Fisher.** 1999. Mammals of Alberta. Lone Pine Publishing, Edmonton, Alberta. 240 pages.

Rand, A. L. 1948. Mammals of the eastern Rockies and western plains of Canada (Bulletin No. 108). National Museum of Canada, Ottawa, Ontario. 237 pages.

Shaw, H. G., P. Beier, M. Culver, M. Grigione. 2007. Puma Field Guide: A guide covering the Biological Considerations, General Life History, Identification, Assessment, and Management of *Puma concolor*. The Cougar Network, Concord, Massachusetts. 129 pages.

Smith, H. C. 1993. Alberta Mammals: An Atlas and Guide. The Provincial Museum of Alberta, Edmonton, Alberta. 239 pages.

Soper, J. D. 1964. The mammals of Alberta. The Hamley Press Ltd. Edmonton, Alberta. 402 pages.

Tumlinson, R. 1987. *Felis lynx*. Mammalian Species 269: 1-8.

Woelfl, M., and **S. Woelfl.** 1994. Evidence of Bobcats, *Lynx rufus*, in southeastern Alberta. Canadian Field-Naturalist 108(4): 495-496.

Received 21 April 2010
Accepted 22 June 2010

Blanding's Turtle, *Emydoidea blandingii,* Habitat Use During Hibernation in Eastern Ontario

DAVID C. SEBURN

Seburn Ecological Services, 2710 Clarenda Street, Ottawa, Ontario, K2B 7S5 Canada; e-mail: davidseburn@sympatico.ca

Seburrn, David C. 2010. Blanding's Turtle, *Emydoidea blandingii,* habitat use during hibernation in eastern Ontario. Canadian Field-Naturalist 124(3): 263–265.

Seven Blanding's Turtles (*Emydoidea blandingii*) were followed using radiotelemetry to determine their habitat use during hibernation near Ottawa, Ontario. During May to August, five of the seven turtles occupied wetlands in which they would eventually hibernate. The turtles hibernated in five different wetlands: three in Organic Shallow Marsh Ecosites and two in Organic Thicket Swamp Ecosites. One Blanding's Turtle over-wintered in a temporary marsh that did not form until October. Blanding's Turtles do not appear to be limited in their choice of suitable hibernation sites even near the northern range limit of the species.

Key Words: Blanding's Turtle, *Emydoidea blandingii,* habitat, hibernation, Ontario.

The Blanding's Turtle (*Emydoidea blandingii*) is commonly found in association with shallow wetlands with an organic bottom and abundant aquatic vegetation (Ernst and Lovich 2009). It generally uses a variety of wetland types (Piepgras and Lang 2000, Joyal et al. 2001), with individuals occupying up to 20 wetlands per year (Beaudry et al. 2009). The Blanding's Turtle is a species of conservation concern across much of its range and in Canada populations in Ontario and Quebec are designated threatened by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC 2005*). To protect Blanding's Turtle habitat effectively it is important to identify all habitats used throughout the year. While Blanding's Turtles move from summer wetlands to different wetlands for hibernation in some populations (e.g., Piepgras and Lang 2000), in other populations most individuals hibernate within their summer wetlands (e.g., Joyal et al. 2001). The purpose of the current research, part of a larger study on habitat use on federal land, was to determine habitat use during hibernation at the northern edge of the range.

Study Area and Method

The study was undertaken at the Shirleys Bay Crown Game Preserve located along the Ottawa River (45.38°N, 75.92°W) west of Ottawa, Ontario. The preserve consists of a variety of wetlands and upland forest and is over 1000 ha in size. It is part of the Connaught Ranges and Primary Training Centre, an active military site of the Department of National Defence.

Blanding's Turtles were caught by hand and sexed using plastron shape and vent position (Ernst and Lovich 2009). All turtles less than 18 cm plastron length were deemed to be juveniles (e.g. Graham and Doyle 1977). As size at maturity varies, this may have resulted in some mature females being deemed juveniles. Turtles were outfitted with Holohil SI-2F radio transmitters. Each 12 g transmitter accounted for less than 5% of the turtle's weight. Transmitters were attached to the rear edge of the carapace using 5-Minute Epoxy (Lepage 12). Waterproof epoxy (PC-7) was then molded to the transmitter to "streamline" its shape, hide its brass casing, and seal any edges which might otherwise get entangled on plant material. Turtles were released at their capture site and subsequent tracking occurred on foot using a TRX-2000S radio receiver and a three-element Yagi antenna. In general, tracking occurred once or twice per week, from time of first capture until late October and then one final time after first snowfall (11 December). Turtles were re-located the following spring to confirm their hibernation location, their survival and to remove transmitters. Tracking in some or all areas was prevented at times because of military exercises. All wetlands used by Blanding's Turtles were classified according to the land classification guide for the province of Ontario (Lee et al. 1998).

Results

Blanding's Turtles were captured from 7 May to 3 June 2007. Six of the turtles were captured in 4 different wetlands, separated by up to 2 km. The remaining turtle was captured on land. Radio transmitters were attached to 4 females (mean = 21 cm plastron length, PL), 2 males (mean = 20 cm PL) and 1 large juvenile (17 cm PL).

Only 1 of the 6 turtles originally caught in a wetland hibernated in the wetland where it was first caught. During May to August, 5 of the 7 turtles occupied wetlands they would eventually hibernate in. Two of the turtles left these wetlands only to return later in the season: one by the end of August, and the other after 10 October. No turtle changed wetlands after 26 October.

The 7 turtles hibernated in 5 different wetlands. Three of the 5 wetlands used for hibernating were Organic Shallow Marsh Ecosites (dominated by Cattails, *Typha latifolia*). The remaining 2 wetlands were both Organic Thicket Swamp Ecosites (dominated by Speckled Alder, *Alnus incana*, and willow, *Salix* spp.).

Although Blanding's Turtles occupied a number of other wetlands, the only other wetland type used was Maple Organic Deciduous Swamp Ecosite. This type of wetland dried up during June, prompting the movement of turtles.

The 2 largest hibernation sites (> 2 ha) each had 2 radio-tracked turtles hibernating within them. Radio-tracked turtles in the same wetland were not hibernating communally, but were less than 20 m apart. It is noteworthy that one adult female left a large permanent marsh to hibernate in a temporary marsh adjacent to it. This site did not fill with rain until October, but the turtle was first tracked there on 28 September, on dry land. On 1, 5 and 10 October she was tracked to a third wetland, returning to the temporary wetland between 10 and 26 October.

Discussion

Blanding's Turtles hibernated in marshes and shrub swamps in the current study. Other studies have found Blanding's Turtles to hibernate in a wide variety of locations, including "permanent pools" (Joyal et al. 2001), ponds (Ross and Anderson 1990), marshes (Edge et al. 2009), shrub swamps (Sajwaj and Lang 2000; Kiviat et al. 2004), Red Maple (*Acer rubrum*) swamps (Joyal et al. 2001, Kiviat et al. 2004), bogs and fens (Edge et al. 2009; Newton and Herman 2009), spring fed ponds (Kiviat et al. 2004), and streams (Newton and Herman 2009). The choice of one of the turtles in this study to hibernate in a small temporary marsh is in contrast to the other more permanent wetlands used by individuals in this study or other studies previously cited. The fact that the turtle moved to the wetland before it filled with water suggests that the turtle was familiar with the wetland and had probably hibernated there previously. To the best of my knowledge, this represents the first documented use by Blanding's Turtles of such an ephemeral wetland for hibernation, although Conant (1951) reported two individuals hibernating on land under wet leaves at the Toledo Zoo.

The fact that Blanding's Turtles hibernated in a range of wetland types and sizes suggests that hibernation sites were not limiting at this location. In their review of turtle winter ecology, Ultsch and Reese (2008) concluded that suitable hibernacula are likely not a limiting factor for turtle species that are anoxia tolerant. Although quantitative studies on anoxia tolerance of Blanding's Turtles have not been undertaken, field studies suggest it is anoxia tolerant (e.g., Sajwaj and Lang 2000, Edge et al. 2009, Newton and Herman 2009).

In this study, five of seven Blanding's Turtles hibernated within wetlands they used during the spring or summer. Similarly, 10 of 14 Blanding's Turtles in Maine hibernated within their summer range (Joyal et al. 2001). Nonetheless, identification of wetlands used by Blanding's Turtles based strictly on observations of basking individuals will likely underestimate the total habitat used and may exclude some hibernation sites. Given the fidelity Blanding's Turtles demonstrate to hibernation sites (e.g., Kiviat et al. 2004; Edge et al. 2009; Newton and Herman 2009) such an oversight could result in a lack of protection for important habitats.

Acknowledgments

Funding for this project was provided by the Interdepartmental Recovery Fund of Environment Canada. I am grateful to the Department of National Defence for granting permission to work on their land and to the National Capital Commission for coordinating the project. All animal handling and transmitter attachment techniques were approved by the Wildlife Animal Care Committee of the Ontario Ministry of Natural Resources. Permission to conduct research on Blanding's Turtles on federal land was granted by Canadian Wildlife Service, Ontario Region. I am also deeply indebted to Mr. Bill Bower for introducing me to Blanding's Turtles on the base. His knowledge and enthusiasm about the base and the turtles greatly aided my work. I am also grateful to Carolyn Seburn and Eric Snyder for assisting with the fieldwork.

Documents Cited (marked * in text)

COSEWIC. 2005. COSEWIC assessment and update status report on the Blanding's Turtle *Emydoidea blandingii* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. viii + 40 pages.

Literature Cited

Conant, R. 1951. The Reptiles of Ohio. Second edition. University of Notre Dame Press, Notre Dame. 284 pages.

Edge, C. B., B. D. Steinberg, R. J. Brooks, and **J. D. Litzgus.** 2009. Temperature and site selection by Blanding's Turtles (*Emydoidea blandingii*) during hibernation near the species' northern range limit. Canadian Journal of Zoology 87: 825-834.

Ernst, C. H., and **J. E. Lovich.** 2009. Turtles of the United States and Canada. Second edition. Johns Hopkins University Press, Baltimore. 827 pages.

Graham, T. E., and **T. S. Doyle.** 1977. Growth and population characteristics of Blanding's turtle, *Emydoidea blandingii*, in Massachusetts. Herpetologica 33: 410-414.

Joyal, L. A., M. McCollough, and **M. L. Hunter, Jr.** 2001. Landscape ecology approaches to wetland species conservation: a case study of two turtle species in southern Maine. Conservation Biology 15: 1755–1762.

Kiviat, E., G. Stevens, K. L. Munger, L.T. Heady, S. Hoeger, P.J. Petokas, and **R. Brauman.** 2004. Blanding's turtle response to wetland and upland habitat construction. Pages 93-99, *in* Conservation and Ecology of Turtles of the Mid-Atlantic Region: A Symposium. *Edited by* C. W. Swarth, W. M. Roosenburg, and E. Kiviat. Bibliomania, Salt Lake City.

Lee, H. T., W. D. Bakowsky, J. Riley, J. Bowles, M. Puddister, P. Uhlig, and **S. McMurray.** 1998. Ecological Land Classification for Southern Ontario: First Approximation and Its Application. Ontario Ministry of Natural Resources, Southcentral Science Section, Science Development and Transfer Branch. SCSS Field Guide FG-02.

Newton, E. J., and **T. B. Herman.** 2009. Habitat, movements, and behaviour of overwintering Blanding's turtles (*Emydoidea blandingii*) in Nova Scotia. Canadian Journal of Zoology 87: 299-309.
Piepgras, S. A., and **J. W. Lang.** 2000. Spatial ecology of Blanding's Turtle in central Minnesota. Chelonian Conservation and Biology 3: 589–601.
Ross, D. A., and **R. K. Anderson.** 1990. Habitat use, movements and nesting of *Emydoidea blandingii* in central Wisconsin. Journal of Herpetology 24: 6-12.
Sajwaj, T. D., and **J. W. Lang.** 2000. Thermal ecology of Blanding's turtle in central Minnesota. Chelonian Conservation and Biology 3: 626–636.
Ultsch, G. R., and **S. A. Reese.** 2008. Ecology and physiology of overwintering. Pages 91-99 *in* Biology of the Snapping Turtle (*Chelydra serpentina*). *Edited by* A. C. Steyermark, M. S. Finkler, and R. J. Brooks. Johns Hopkins University Press, Baltimore.

Received 16 June 2010
Accepted 14 October 2010

Scavenging by a Bobcat, *Lynx rufus*

STEVEN G. PLATT[1], GERARD T. SALMON[2], STANLEE M. MILLER[3], and THOMAS R. RAINWATER[4]

[1] Department of Biological Sciences, P.O. Box C-64, Sul Ross State University, Alpine, Texas 79832 USA; e-mail: splatt@sulross.edu
[2] P.O. Box 167, Boerne, Texas 78006 USA
[3] Campbell Museum of Natural History, Clemson University, Clemson, South Carolina, 29634 USA
[4] Department of Obstetrics and Gynecology, Medical University of South Carolina, Rollings Marine Laboratory, 333 Ft. Johnson Road, Charleston, North Carolina 29412 USA

Platt, Steven G., Gerard T. Salmon, Stanlee M. Miller, and Thomas R. Rainwater. 2010. Scavenging by a Bobcat, *Lynx rufus*. Canadian Field-Naturalist 124(3): 265–267.

There are few available reports of scavenging (carrion foraging) by Bobcats (*Lynx rufus*). We recovered the remains of a Gray Squirrel (*Sciurus carolinensis*) from the stomach of a road-killed female Bobcat in Dutchess County, New York. The presence of Blow Fly eggs on the squirrel remains indicate that it was consumed as carrion. To our knowledge this is the third confirmed instance of scavenging by a Bobcat.

Key Words: Bobcat, *Lynx rufus*, scavenging, carrion, diet, food habits, blow fly, Calliporidae.

Scavenging (carrion foraging) by terrestrial vertebrates is more prevalent than generally recognized, and rather than a curiosity of animal behavior it is an ecological process that must be accounted for (DeVault et al. 2003). Dietary studies of carnivores usually rely on analyses of stomach contents and scats; however, because these methodologies can reveal the composition of the diet, but not the foraging mode, most scavenging events probably go undetected (DeVault and Rhodes 2002). Given the difficulties inherent in detecting scavenging behavior, and the need to identify scavengers in order to understand scavenging as a trophic pathway (DeVault and Rhodes 2002; Selva and Fortuna 2007), field observations of scavenging are especially noteworthy (Logan and Montero 2009).

The Bobcat (*Lynx rufus*) is a medium-sized felid widely distributed in North America, occurring from southern Canada to central Mexico, and throughout most of the United States (Larivière and Walton 1997). Bobcats are obligate carnivores and their food habits have been well-studied in much of this geographic range (Delibes et al. 1997; Anderson and Lovallo 2003). In most areas the diet consists principally of lagomorphs, but sciurids, other rodents, and larger mammals such as ungulates are also consumed (Anderson and Lovallo 2003; Hansen 2007). Bobcats are adept predators that generally kill living prey; however, scavenging is known to occur, although there are few reports of this behavior in the literature. Fritts and Sealander (1978) report that a Bobcat was collected after feeding on a road-killed White-tailed Deer (*Odocoileus virginianus*), and others (Rollings 1945; Pollack 1951; Lowery 1974) suggest that most deer eaten by Bobcats are consumed as carrion, which becomes available when animals are lost by hunters or die of starvation during the winter. Beaver (*Castor canadensis*) carcasses are used to lure Bobcats into traps (Hawbaker 1974), and DeVault and Rhodes (2002) photographed a Bobcat consuming a small mammal carcass during experimental trials designed to identify vertebrate scavengers. Here we provide an additional record of scavenging by a Bobcat.

On 20 July 2010 (2330 hours) one of the authors (GTS) recovered a road-killed female Bobcat on State Highway 44 near the intersection with South Road in Washington Township, Dutchess County, New York (41°46'818"N; 73°44'942"W). The carcass was not present when GTS passed the site at 2300 hours; therefore the Bobcat had been dead less than 30 minutes when it was found. We measured (following Hall 1962; total length = 770 mm; tail length = 125 mm; rear-foot length = 155 mm; ear = 60 mm) and skinned the Bobcat, which was deposited in the Campbell Museum, Clemson University, Clemson, South Carolina (CUSC

4243). The stomach of the Bobcat contained the remains of a recently ingested Gray Squirrel (*Sciurus carolinensis*). Numerous Blow Fly (Calliphoridae) eggs evident in the fur of the squirrel (Figure 1) indicate that it was consumed as carrion rather than killed as prey. Because Blow Flies usually oviposit on carrion within a few hours of death, and eggs hatch 24 to 36 hours after being deposited (Smith 1986), the squirrel carcass was probably 1-2 days old when consumed by the Bobcat.

To our knowledge, this observation constitutes only the third confirmed instance of scavenging by a Bobcat (see also Fritts and Sealander 1978; DeVault and Rhodes 2002). Scavenging likely occurs more frequently than suggested by the few available reports; however, the limitations of traditional dietary studies mean that except in rare instances such as this one, scavenging cannot be distinguished from predation. Although Bobcats probably consume most prey after capturing and killing it, opportunistic scavenging is not unexpected when carrion is available, and can make important energetic contributions to the diet (Bauer et al. 2005). Furthermore, scavenging is beneficial from the standpoint of individual fitness because consuming carrion requires a minimal energetic investment in comparison to hunting and killing prey, and the risk of injury from prey is eliminated (DeVault and Rhodes 2002; Bauer et al. 2005). Of course carrion consumption also entails certain costs; most notably scavengers must compete with decomposers, and risk exposure to toxins and disease-causing microbes in carrion (Schaller and Lowther 1969; DeVault et al. 2003; Shivik 2006). Because carrion is an ephemeral resource that generally occurs at low densities, it is unlikely that Bobcats or other terrestrial carnivores could meet their energetic requirements solely by scavenging (DeVault et al. 2003). Indeed, the only known obligate vertebrate scavengers are Old and New World vultures, which are specialized for low-energy soaring flight and can search large areas for carrion far more efficiently than mammalian scavengers (DeVault et al. 2003; Ruxton and Houston 2004; Shivik 2006).

In addition to Bobcats, scavenging behavior has been documented among other small and large felids. Both Canada Lynx (*Lynx canadensis*) and European Lynx (*L. lynx*) are known to scavenge ungulate carcasses (Anderson and Lovallo 2003; Selva and Fortuna 2007). In one study of Canada Lynx, ungulate carrion comprised 17% of the diet (Nellis and Keith 1968). Scavenging by African Lions (*Panthera leo*) is common (Schaller 1972). According to Perry (1965), Tigers (*Panthera tigris*) are "habitual carrion eaters", that frequently scavenged human bodies from World War II battlefields in India and Burma. Similarly, Bazé (1957) observed Tigers consuming decomposing Asian Elephants (*Elephas maximus*) and Water Buffalo (*Bubalus bubalis*). Scavenging by Puma (*Puma concolor*) is well documented (Robinette et al. 1959; Ackerman et al. 1984; Logan and Sweanor 2001). In a radio telemetry study, Bauer at al. (2005) found that Puma scavenged 43.5% of monitored Mule Deer (*Odocoileus hemionus*) carcasses ranging from "frozen and fresh to rotting and maggot-infested". Indeed it is likely that most, if not all felids will consume carrion if available (Kitchener 1991), although additional field observations and experimental studies are required for confirmation.

FIGURE 1. Gray Squirrel (*Sciurus carolinensis*) remains recovered from the stomach of a road-killed Bobcat (*Lynx rufus*) in Dutchess County, New York (20 July 2010). Note the abundant Blow Fly (Calliphoridae) eggs. Photo by Gerard T. Salmon.

Acknowledgments

We thank Linda Epps and the interlibrary loan staff at Sul Ross State University for assistance in obtaining literature, Bryan Htut for assisting with preparation of the bobcat skin, and Christopher Ritzi and Melinda Dooley for identifying the Dipteran eggs. An early draft of this note benefited from the comments of Lewis Medlock, Travis DeVault, and an anonymous reviewer.

Literature Cited

Ackerman, B. B., F. G. Lindzey, and **T. P. Hemker.** 1984. Cougar food habits in southern Utah. Journal of Wildlife Management 48: 147-155.

Anderson, E. M., and **M. J. Lovallo.** 2003. Bobcat and lynx. Pages 758-786 *in* Wild Mammals of North America: Biology, Management, and Conservation. 2nd Edition. *Edited by* G. A. Feldhamer, B. C. Thompson, and J. A. Chapman. Johns Hopkins University Press, Baltimore, Maryland.

Bauer, J. W., K. A. Logan, L. L. Sweanor, and **W. M. Boyce.** 2005. Scavenging behavior in Puma. Southwestern Naturalist 50: 466-471.

Bazé, W. 1957. Tiger! Tiger! Abelaerd-Schuman Ltd., New York. 197 pages.

Delibes, M., M. C. Blazquez, R. Rodrigues-Estrella, and **S. C. Zapata.** 1997. Seasonal food habits of Bobcats (*Lynx rufus*) in subtropical Baja California Sur, Mexico. Canadian Journal of Zoology 74: 478-483.

DeVault, T. L., and **O. E. Rhodes, Jr.** 2002. Identification of vertebrate scavengers of small mammal carcasses in a forested landscape. Acta Theriologica 47: 185-192.

DeVault, T. L., O. E. Rhodes, Jr., and **J. A. Shivik.** 2003. Scavenging by vertebrates: behaviorial, ecological, and evolutionary perspectives on an important energy transfer pathway in terrestrial ecosystems. Oikos 102: 225-234.
Fritts, S. H., and **J. A. Sealander.** 1978. Diets of bobcats in Arkansas with special reference to age and sex differences. Journal of Wildlife Management 42:533-539.
Hall, E. R. 1962. Collecting and preparing study specimens of vertebrates. University of Kansas, Museum of Natural History, Miscellaneous Publication 30.
Hansen, K. 2007. Bobcat: Master of Survival. Oxford University Press, Inc., New York. 212 pages.
Hawbaker, S. S. 1974. Trapping North American Furbearers. Kurtz Brothers, Clearfield, Pennsylvania. 352 pages.
Kitchener, A. 1991. The Natural History of the Wild Cats. Cornell University Press, Ithaca, New York. 280 pages.
Larivière, S., and **L. R. Walton.** 1997. *Lynx rufus.* Mammalian Species 563:1-8.
Logan, C. J., and **C. Montero.** 2009. *Bothrops asper* (Terciopelo). Scavenging behavior. Herpetological Review 40: 352.
Logan, K. L., and **L. L. Sweanor.** 2001. Desert Puma: Evolutionary Ecology and Conservation of an Enduring Carnivore. Island Press, Washington, D.C. 463 pages.
Lowery, G. H., Jr. 1974. The Mammals of Louisiana and its Adjacent Waters. Louisiana State University Press, Baton Rouge. 565 pages.
Nellis, C. H., and **L. B. Keith.** 1968. Hunting activities and success of lynxes in Alberta. Journal of Wildlife Management 32: 718-722.
Perry, R. 1965. The World of the Tiger. Atheneum Press, New York. 261 pages.
Pollack, E. M. 1951. Food habits of bobcats in New England states. Journal of Wildlife Management 15: 209-213.
Robinette, W. L., J. S. Gashwiler, and **O. W. Morris.** 1959. Food habits of cougar in Utah and Nevada. Journal of Wildlife Management 23: 261-273.
Rollings, C. T. 1945. Habits, foods and parasites of the bobcat in Minnesota. Journal of Wildlife Management 9: 131-145.
Ruxton, G. D., and **D. C. Houston.** 2004. Obligate vertebrate scavengers must be large soaring fliers. Journal of Theoretical Biology 228: 431-436.
Schaller, G. B. 1972. The Serengeti Lion. Chicago University Press, Chicago. 480 pages.
Schaller, G. B., and **G. R. Lowther.** 1969. The relevance of carnivore behavior to the study of early Hominids. Southwestern Journal of Anthropology 25: 307-341.
Selva, N., and **M. A. Fortuna.** 2007. The nested structure of a scavenger community. Proceedings of the Royal Society (B) 274: 1101-1108.
Shivik, J. A. 2006. Are vultures birds, and do snakes have venom, because of macro- and microscavenger conflict? Bioscience 56: 819-823.
Smith, K. G. V. 1986. A Manual of Forensic Entomology. Cornell University Press, New York. 205 pages.

Received 17 October 2010
Accepted 5 November 2010

Northeastern Range Extension for the Northern Redbelly Dace, *Phoxinus eos*, and the Golden Shiner, *Notemigonus crysoleucas*, in Québec

JEAN-FRANÇOIS DESROCHES

Cégep de Sherbrooke, Techniques de bioécologie, 475 rue du Cégep, Sherbrooke, Québec J1E 4K1 Canada

Desroches, Jean-François. 2010. Northeastern range extension for the Northern Redbelly Dace, *Phoxinus eos* and the Golden Shiner, *Notemigonus crysoleucas*, in Québec. Canadian Field-Naturalist 124(3): 268–270.

In 2005 and 2009, two species of Cyprinidae, the Northern Redbelly Dace, *Phoxinus eos*, and the Golden Shiner, *Notemigonus crysoleucas*, were collected northeast of their know range, in Québec. These new records, indeed range extensions, are presented here with a short discussion on the fish fauna of the area and on the possibility of introductions.

En 2005 et en 2009, deux espèces de Cyprinidés, soit le Méné ventre-rouge, *Phoxinus eos*, et le Méné jaune, *Notemigonus crysoleucas*, ont été capturées au nord-est de leur répartition connue au Québec. Ces nouvelles mentions, qui constituent des extensions d'aire, sont ici présentées de même qu'une courte discussion sur l'ichtyofaune de la région et la possibilité d'introductions.

Key Words: Northern Redbelly Dace, *Phoxinus eos*, Golden Shiner, *Notemigonus crysoleucas*, range extension, habitat, Québec.

Ichtyological surveys have been done extensively in southwestern Québec and all along the St. Lawrence River, but many remote areas of the Québec territory have not received much attention, particularly in regard to smaller species such as the cyprinids. This is, in part, due to their low economic importance in these areas, but also because these fishes are often hard to identify, and are not of interest to anglers, except as bait. This has resulted in a poor knowledge of the distribution for many species, mostly in northern areas where aquatic habitats suitable for them are located far from human settlements, and where access to lakes and rivers is often difficult.

In 2005 and 2009, during holiday surveys in the Côte-Nord region of Québec, two species of Cyprinidae, the Northern Redbelly Dace, *Phoxinus eos*, and the Golden Shiner, *Notemigonus crysoleucas,* not previously reported from that area, were caught. Voucher specimens have been preserved in the fish collection of the Canadian Museum of Nature (CMNFI-#). Ichtyological databases associated with the collections of the Canadian Museum of Nature, the Ministère des Ressources naturelles et de la faune du Québec and the New Brunswick Museum were investigated in May 2010 in order to be certain that there were no unpublished records of these species in that area.

The Northern Redbelly Dace was found in the Rivière Amédée, at Baie-Comeau (49°12'19"N, 68° 15'32"W) just north of road 138 (Figure 1). This represent a 300 km northeast (from Québec City area) and 275 km north-east-east (from north side of Lake Saint-Jean) range extension for the species (see maps in Scott and Crossman 1998 and Bernatchez and Giroux 2000). On 29 July 2009 about 10 Northern Redbelly Daces were caught with a dipnet with five young Golden Shiners. On 5 August 2009, at the exact same place, two specimens of Redbelly Daces were collected, photographed, and preserved (CMNFI-2009-0136). The habitat is similar with those in southern Québec. The river at that location is about 80 m large, with low current (none in small bays), semi-turbid water, and muddy bottom. The aquatic emergent vegetation is mostly Cattails (*Typha sp.*) and Sweet Gale (*Myrica gale*).

The Golden Shiner was observed at Lac Yvette in 2005 and in three stations in Rivière Amédée in 2009 (Figure 2). These two sites are at about 110 km (lac Yvette) and 130 km (Rivière Amédée) northeast of the previously know distribution of the species in Québec (see maps in Scott and Crossman 1998 and Bernatchez and Giroux 2000). On 5 July 2005, three minnow traps set at Lac Yvette, Ragueneau Township (49°12'50"N, 68°26'56"W), captured 27 Golden Shiners and 14 young Yellow Perch (*Perca flavescens*). Ten specimens were preserved (CMNFI-2009-0104). This lake is clear and surrounded by forest.

In 2009, Golden Shiner were found at three different stations in the Rivière Amédée at Baie-Comeau. On 29 July, five young were caught with a dipnet, with about 10 Northern Redbelly Dace (49°12'19"N, 68°15'32"W) north of the road 138. A minnow trap was then placed there and on 31 July another Golden Shiner was captured. The habitat is described in the previous paragraph (Northern Redbelly Dace). On 29 July, south of the road 138, a young Golden Shiner was caught with dipnet (49°12'14"N, 68°15'10"W). A minnow trap was put at that place and removed on 31 July. It contained 13 Golden Shiners (12 adults and one young) and one young Yellow Perch. The habitat there is similar to the usual habitats of the species. The river is about 60 m wide at that point, with low to no current, the water is semi-turbid, the bottom is muddy, and principal aquatic plants are *Myriophyllum* sp., *Potamogeton* sp. and *Utricularia vulgaris*. Finally,

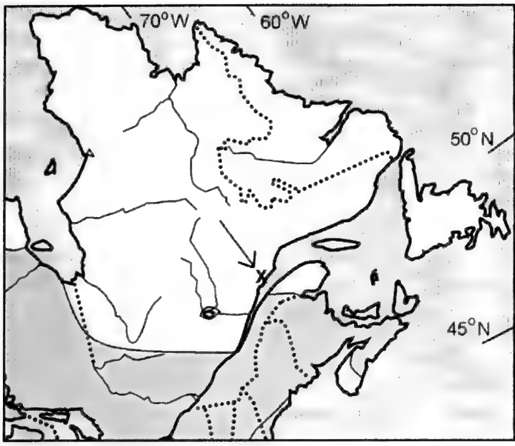


FIGURE 1. Distribution of the Redbelly Dace (*Phoxinus eos*) in Québec and adjacent territories (modified from Scott and Crossman 1998 and Bernatchez and Giroux 2000). The X is the new location from the present note.

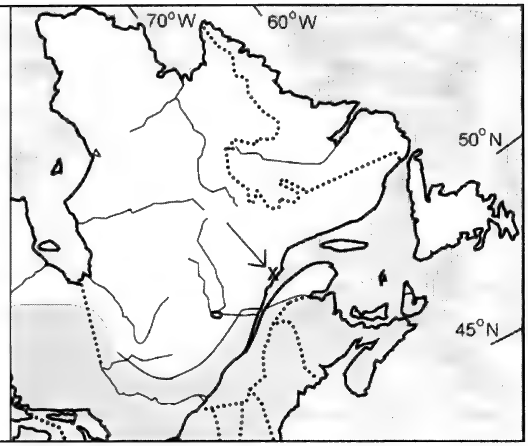


FIGURE 2. Distribution of the Golden Shiner (*Notemigonus crysoleucas*) in Québec and adjacent territories (modified from Scott and Crossman 1998 and Bernatchez and Giroux 2000). The X is the new locations from the present note.

a third station located more downstream in the Rivière Amédée (49°11'43"N, 68°14'46"W), just upstream of a bridge, allowed the discovery of the Golden Shiner. On 29 July 2009, three young Golden Shiners were caught with a dipnet, and two minnow traps left there captured one other specimen (adult) and eight young Yellow Perch. The river at that location is 50 m wide, with very low current, water ¾ clear, bottom of sand and gravel covered with organic matter. Some floating *Potamogeton* were noticed.

These new records are interesting range extensions, especially that of the Northern Redbelly Dace. This fish was not known east of Québec City area, on the north shore of the St. Lawrence River, except for Lac St-Jean. The small fish fauna has been poorly surveyed in these areas, and the discovery of new localities disjunct from their previously know range is probably often due to the fact these species have not been looked for there before. Neverthless, like the similar range extension of the Central Mudminnow (*Umbra limi*) (Desroches 2006), the possibility of anthropogenic introductions cannot be completely ignored. The Northern Redbelly Dace and the Golden Shiner are popular bait for game fishes, especially for the Walleye (*Sander vitreus*) but also for pike and trout (Bernatchez and Giroux 2000). These fishes are all present in the area where the two species of minnows (Northern Redbelly Dace and Golden Shiner) were discovered. The exact habitat where the minnows were found is not suitable for Walleye, pike and trout, at least at the Rivière Amédée, and the source of these minnow populations, if from introductions, would have had to be from far upstream.

Neither species were found in a 2009 short investigation of two well known lakes in the area for the Brook Trout (*Salvelinus fontinalis*), a highly popular sport fish, but did indicate the presence of the Lake Chub (*Couesius plumbeus*). The Lake Chub live in similar habitats than trout, i.e., clear waters and sandy to gravely bottom, and it is not surprising that they would be found sympatrically with Brook Trout.

Examples of isolated populations of fishes are common. They are often explained by the fact that aquatic habitats were strongly modified in geological times, and some giant lakes became fractioned in smaller ones, when the water level decreased in eastern North America (Moyle and Cech 2004). They are also often the site of anthropogenic voluntary or accidental introductions. In the case of small species of no direct economical value that are difficult to accurately identify, it can often be difficult to confirm or refute that these populations are naturally present at one place. The best thing to be done is to continue meticulous periodic surveys, as well as the undertaking of genetic studies to determine the links between populations. New records from outside known ranges, should be supported with voucher specimens or photographs.

Acknowledgments

The author is grateful to Sylvie Laframboise, assistant collection manager at the Canadian Museum of Nature, Jean Dubé, retired from the Ministère des Ressources naturelles et de la faune du Québec, and to Donald McAlpine and Mary Sollows, respectively research curator and curatorial assistant in zoology at the New Brunswick Museum, for access to the official databases.

Literature Cited

Bernatchez, L., et **M. Giroux.** 2000. Les poissons d'eau douce du Québec et leur répartition dans l'est du Canada. Broquet inc., Boucherville, Québec. 350 pages.

Desroches, J.-F. 2006. Extension de l'aire de distribution de l'Umbre de vase, *Umbra limi*, dans le nord-est du Québec. Canadian Field-Naturalist 120 : 238-239.

Moyle, P. B., and **J. J. Cech.** 2004. Fishes: an introduction to ichthyology. Prentice Hall, Upper Saddle River, New Jersey. 726 pages.

Scott, W. B., and **E. J. Crossman.** 1998. Freshwater fishes of Canada. Galt House Publications Ltd., Oakville, Ontario. 966 pages.

Received 27 October 2009
Accepted 22 October 2010

Predation of a Barren-ground Caribou, *Rangifer tarandus groenlandicus*, by a Single Gray Wolf, *Canis lupus*, in Northern Manitoba, Canada

BRIAN W. KISS[1], SCOTT K. JOHNSTONE[2], and ROBERT P. BERGER[3]

[1]22 White Pine Place, Winnipeg, Manitoba R2R 2G6 Canada
[2]Manitoba Floodway and East Side Road Authority, Manitoba Conservation, 7-1333 Niakwa Road East, Winnipeg, Manitoba R2J 3T5 Canada.
[3]Wildlife Resource Consulting Services MB Inc., 495-B Madison Street, Winnipeg, Manitoba R3J 1J2 Canada

Kiss, Brian W., Scott K. Johnstone, and Robert P. Berger. 2010. Predation of a Barren-Ground Caribou, *Rangifer tarandus groenlandicus,* by a Single Gray Wolf, *Canis lupus*, in Northern Manitoba. Canadian Field-Naturalist 124(3): 270–271.

A single Gray Wolf (*Canis lupus*) was observed successfully trapping and predating a Barren-ground Caribou (*Rangifer tarandus groenlandicus*) in a small section of open water.

Key Words: Gray Wolf, *Canis lupus*, Barren-ground Caribou, *Rangifer tarandus groenlandicus*, predation, Manitoba.

Thousands of animals from the Qamanirjuaq Barren-ground Caribou (*Rangifer tarandus groenlandicus*) herd migrate annually from the arctic tundra of Nunavut and northern Manitoba, Canada south into the subarctic taiga of Manitoba where they spend a large portion of the winter months (Parker 1973; BQCMB 1999). Barren-ground Caribou in central Canada that migrate south of the tree line are preyed upon by both resident Gray Wolf (*Canis lupus griseoalbus*) populations and Barren-ground Gray Wolves (*Canis lupus hudsonicus*) that follow the caribou migration (Kelsall 1968; Miller 1975; Walton et al. 2001).

The following is a description of a wolf – caribou interaction observed along a section of open water at Innes-Taylor Rapids on the Little Churchill River in northern Manitoba (56°56'N, 95°41'W). The interaction was observed opportunistically from a Bell 206 JetRanger helicopter during a Moose (*Alces alces*) aerial survey training flight. Although other observations of caribou killed by a single wolf have been previously documented (e.g., Murie 1944, Burkholder 1959; Dauphine 1969; Smith 1980), it is to our knowledge that observational notes of a caribou trapped and predated by a single wolf in a small body of open water are previously unpublished.

On 28 February 2009, an adult female Barren-ground Caribou was observed standing in a small section of open water near the flow edge on the Little Churchill River. The area of open water was oriented in a northwest to southeast direction, measuring approximately 20 m in width by 100 m in length. Upon first observation, the caribou appeared motionless and covered with icicles. A Gray Wolf was then observed running towards the caribou, advancing from the nearest treed shoreline. The caribou reacted to the wolf by swimming across the river to the opposite side of the ice bank. The wolf responded to the caribou's movements by travelling along the ice edge to the area where the caribou was now attempting to climb ashore. As the wolf approached, the caribou retreated back into the open water. Numerous wolf tracks following the flow edge and a considerable amount of ice attached to the caribou's pelage suggested that the chase had been taking place for a considerable length of time. At this point, we believe the helicopter, located approximately 350 m away, disturbed the wolf. It retreated into a nearby stand of trees and was undetectable from our vantage point. The caribou was then able to climb ashore and stood motionless along the flow edge, until we departed the site for approximately one hour.

Upon returning to the site we observed that the caribou had returned to the water and the wolf was once again standing along the flow edge. Blood stains in the snow where the caribou had stood before our departure, and an open wound visible on the right hindquarter of the caribou, indicated that a struggle had occurred prior to our return. We then witnessed the weakened caribou, likely suffering from exhaustion and hypothermia, attempt to exit the water only meters from where the wolf was standing. The wolf took hold of the caribou, biting it on the front left portion of the shoulder near the neck. A short struggle ensued thereafter, ending in the death of the caribou.

The current of the flowing river began forcing the dead caribou under the ice. In order to prevent the caribou from being swept under the ice by the flowing water, the wolf fully submersed its own head into the water, and clinched onto the sinking caribou. The wolf then proceeded to partially drag the caribou up onto the ice. Within moments of stabilizing the caribou, the wolf began consuming the caribou's left front quarter and the neck area. At this point, our helicopter departed the site for the day.

On 3 March 2009, the site was revisited with a fixed-wing aircraft. Based on a limited number of new tracks and from the presence of only a single wolf bed alongside the kill, it appears that only one wolf utilized the kill. The carcass was being scavenged by Common Ravens (*Corvus corax*) at the time and appeared to be approximately 75% consumed. This rate of consumption by a single wolf is supported by Smith's (1980) observation of nearly 100% utilization of a caribou by a single wolf and a few avian scavengers in a 46 hour period.

Track evidence suggested that initially, three caribou fled into the open water after being chased by a pack of wolves. Two caribou appear to have successfully crossed the rapids, exited the water, and were chased by all but one of the wolves across the ice west of the rapids. This left one caribou in the water, and one wolf waiting ashore.

The disturbance by the helicopter during our observations may have caused the wolf to leave the scene, which allowed the caribou to exit the water, and stand ashore where it was attacked and injured upon the wolf's return. Had we not disrupted the hunt, it is possible that continued pursuit by the wolf would have prevented an uninjured caribou from attempting to exit the water, causing it to become severely hypothermic and die by this or drowning. If the caribou had died away from the wolf's grasp, it is possible that the current of the water would have made the carcass inaccessible, negating the success of this chase.

Acknowledgments

We gratefully acknowledge Manitoba Hydro for funding the research and encouraging the publication of this document. We thank Jessie Whitcher from Custom Helicopters who was our pilot during the observation. We appreciate the comments and draft manuscript edits provided Dr. Richard K. Baydack, University of Manitoba and Dr. Robert W. Nero during the development of this publication. Finally, we would like to thank our fellow associates at Wildlife Resource Consulting Services MB Inc. for all of their advice and support.

Literature Cited

BQCMB. 1999. Protecting Beverly Qamanirjuaq Caribou and Caribou Range. Artisan Press Ltd. Yellowknife. 40 pages.

Burkholder, B. L. 1959. Movements and behavior of a wolf pack in Alaska. Journal of Wildlife Management 23: 1-11.

Dauphine, T. C. 1969. A wolf kills a caribou calf. Blue Jay 27: 99.

Kelsall, J. P. 1968. The Caribou. Queen's Printer and Controller of Stationery, Ottawa, Ontario. 340 pages.

Miller, D. R. 1975. Observations of wolf predation on barren ground caribou in winter. Pages 209-220 *in* First International Reindeer and Caribou Symposium. *Edited by* J. R. Luick, P. C. Lent, D. R. Klein, R. G. White, Biological Papers of the University of Alaska, Fairbanks, Alaska.

Murie, A. 1944. The wolves of Mount McKinley (Fauna of the national parks of the United States, Fauna Series Number 5). U.S. National Parks Service, Washington, DC.

Parker, G. R. 1973. Distribution and densities of wolves within barren-ground caribou range in northern mainland Canada. Journal of Mammalogy 54: 341-348.

Smith, T. G. 1980. Hunting, kill, and utilization of a caribou by a single gray wolf. Canadian Field-Naturalist 94: 175-177.

Walton, L R., H. D. Cluff, P. C. Paquet, and **M. A. Ramsay.** 2001. Movement patterns of barren-ground wolves in the central Canadian Arctic. Journal of Mammalogy 82: 867-876.

Received 27 November 2009
Accepted 15 October 2010

Female American Redstart, *Setophaga ruticilla,* Reuses Red-Eyed Vireo, *Vireo olivaceus,* Nest

ANN E. MCKELLAR

Department of Biology, Queen's University, Kingston Ontario K7L 3N6 Canada; e-mail: ann.mckellar@queensu.ca

McKellar, Ann E. 2010. Female American Redstart, *Setophaga ruticilla,* reuses Red-Eyed Vireo, *Vireo olivaceus,* nest. Canadian Field-Naturalist 124(3): 272–273.

Interspecific nest reuse is uncommon in open-cup nesting birds, but has been reported several times in the American Redstart (*Setophaga ruticilla*). Individuals might reuse nests if appropriate nesting sites are limited or in order to conserve time and energy. Here I describe an instance of nest reuse by a female American Redstart of a Red-Eyed Vireo (*Vireo olivaceus*) nest after two previous failed nesting attempts. I argue that Redstarts might be more likely to reuse other species' nests during late-season nesting attempts.

Key Words: American Redstart, *Setophaga ruticilla*, Red-Eyed Vireo, *Vireo olivaceus*, nest reuse, nest-building.

Nest reuse is thought to be an uncommon behaviour in open-cup nesting passerines, possibly due to the deterioration of nest material over time, the presence of ectoparasites in previously used nests (Barclay 1988), and/or the memory of nest sites by predators (Sonerud and Fjeld 1987). Nonetheless, intraspecific nest reuse occurs occasionally both within and between breeding seasons (Marshall et al. 2001; Redmond et al. 2007; Richmond et al. 2007), and interspecific nest reuse has also been reported in some species (Yezerinac 1993; Bergin 1997; Richmond et al. 2007). Such behaviour might occur when nest sites are limited (Redmond et al. 2007) or in circumstances where birds have limited time and energy for nest-building (Gauthier and Thomas 1994; Cavitt et al. 1999). Here I report on an instance of interspecific nest reuse by a female American Redstart (*Setophaga ruticilla*) of a Red-Eyed Vireo (*Vireo olivaceus*) nest.

On 30 June 2010, I observed a female American Redstart beginning nest construction in a small Sugar Maple (*Acer saccharum*) on a property near the Queen's University Biological Station, Chaffey's Lock, Ontario (44°34'N, 76°19'W). I returned on 1 July to find that the previous day's construction had been abandoned. I observed the female carrying nesting material to a nearby location, but I was unable to find the new nest at that time. Then, on 6 July, I found her incubating three eggs in a Red-Eyed Vireo (*Vireo olivaceus*) nest in an American Basswood (*Tilia americana*). Though both species tend to construct nests in sites of similar habitat and height, Vireo nests are often larger than those of Redstarts, and Red-Eyed Vireos construct their nests suspended from a fork or from two lateral twigs on a tree branch (Lawrence 1953), whereas American Redstarts construct their nests at the junction of three or more small branches, often on the main trunk (Ficken 1964). On 10 July, the nest had been depredated. Upon collection, it was clear that the intact Vireo nest had been originally constructed during the same breeding season and that the female Redstart had added her own smaller inner cup and lining material.

Several instances of interspecific nest reuse in American Redstarts have been reported previously. Burtch (1898) observed a female American Redstart using an old Red-Eyed Vireo nest that she had freshly lined, and Birtwell (1899) observed a female Redstart using what was likely a Yellow-Throated Vireo (*V. flavifrons*) nest. Bent (1953) noted three more cases in which Red-Eyed Vireo nests were used, one more in which a Yellow-Throated Vireo nest was used, and one in which a nest started and abandoned by a Yellow Warbler (*Dendroica petechia*) was used. More recently, Yezerinac (1993) observed a female American Redstart reusing a Yellow Warbler nest. Although interspecific nest reuse in American Redstarts is infrequent (e.g., the present case is the only one seen in a 10-year breeding study comprising over 750 nests; A. McKellar and L. Ratcliffe, unpublished data), this appears to be a consistent behaviour.

Why might American Redstarts reuse other species' nests? Nest-site limitation is important in cavity-nesting species (Newton 1994), but it is an unlikely explanation for nest reuse in many open-cup nesters (Yezerinac 1993; Marshall et al. 2001; Richmond et al. 2007; but see Redmond et al. 2007), where nesting sites are often abundant. Alternatively, nest reuse might help to conserve time and energy. American Redstarts are single-brooded and rates of nest loss are high (Sherry and Holmes 1992). With respect to energy conservation, nest construction in American Redstarts takes several days and is estimated to require around 650-700 trips (Sturm 1945), likely making it quite energetically expensive. Redstarts that reuse nests could allocate that energy elsewhere (e.g., Gauthier and Thomas 1994). With respect to timing, American Redstarts that reuse nests might benefit by initiating their clutches earlier (e.g., Cavitt et al. 1999), particularly during the late stages of the breeding season when pairs might otherwise give up. Indeed, the approxi-

mate clutch initiation dates observed by both Yezerinac (1993) and myself occurred quite late in the season (19 June and 2 July at the earliest, respectively, both corresponding to the latest observed first egg date of the season; Yezerinac 1993; A. McKellar, unpublished data). Furthermore, the pair that I observed had already failed at their two previous nesting attempts, which were both depredated during incubation. Though the female was not banded, the male was, and all of their nesting attempts were in close proximity to each other. It is therefore probable that the female began construction of a third nest, quickly abandoned it, and found the used Vireo nest to re-line and lay her clutch in instead. Although detailed information regarding the timing of clutch initiation and number of attempts by the other American Redstarts that reused interspecific nests is not available, it is plausible that Redstarts might be more likely to reuse nests after several failed attempts when the breeding season is nearing an end (Yezerinac 1993). It is perhaps curious that intraspecific nest reuse in Redstarts has never been reported, especially since nests of other species, particularly Vireos, can be much larger and presumably more conspicuous to predators. It may be that territorial species such as Redstarts are simply less likely to encounter intraspecific nests from the same season.

Acknowledgments

I thank Laurene Ratcliffe and Peter Marra for helpful suggestions on the manuscript, and Paul Martin for encouraging me to pursue this topic. My work at the Queen's University Biological Station was funded by the Natural Sciences and Engineering Research Council of Canada, the Society of Canadian Ornithologists, and the American Ornithologists' Union.

Literature Cited

Barclay, R. M. R. 1988. Variation in the costs, benefits, and frequency of nest reuse by Barn Swallows (*Hirundo rustica*). Auk 105: 53-60.

Bent, A. C. 1953. Life histories of North American wood warblers. Dover Publishers, New York, New York, USA.

Bergin, T. M. 1997. Nest reuse by Western Kingbirds. Wilson Bulletin 109: 735-737.

Birtwell, F. J. 1899. Another example of curious nesting of the American Redstart. Auk 16: 184-185.

Burtch, V. 1898. Curious nesting of the American redstart. Auk 15: 332.

Cavitt, J. F., Pearse, A. T., and **T. A. Miller.** 1999. Brown Thrasher nest reuse: a time saving resource, protection from search-strategy predators, or cues for nest-site selection? Condor 101: 859-862.

Ficken, M. S. 1964. Nest-site selection in the American Redstart. Wilson Bulletin 76: 189-190.

Gauthier, M., and **D. W. Thomas.** 1994. Bénéfices associés à la réutilisation des nids chez l'hirondelle à front blanc (*Hirundo pyrrhonota*). Écoscience 1: 119-126.

Lawrence, L. K. 1953. Nesting life and behaviour of the Red-eyed Vireo. Canadian Field-Naturalist 67: 47-77.

Marshall, J. S., Glover, P. A. R., Buechi, K. A., and **L. W. VanDruff.** 2001. Nest reuse by a Gray Catbird. Wilson Bulletin 113: 337-338.

Newton, I. 1994. The role of nest sites in limiting the numbers of hole-nesting birds: a review. Biological Conservation 70: 265-276.

Redmond, L. J., Murphy, M. T., and **A. C. Dolan.** 2007. Nest reuse by Eastern Kingbirds: adaptive behavior or ecological constraint? Condor 109: 463-468.

Richmond, S., Nol, E., Campbell, M., and **D. Burke.** 2007. Conspecific and interspecific nest reuse by Wood Thrush (*Hylocichla mustelina*). Northeastern Naturalist 14: 629-636.

Sherry, T. W., and **R. T. Holmes.** 1992. Population fluctuations in a long-distance Neotropical migrant: demographic evidence for the importance of breeding season events in the American Redstart. Pages 431-442 *in* Ecology and conservation of Neotropical migrant landbirds. *Edited by* J. M. Hagan III and D. W. Johnston. Smithsonian Institution Press, Washington, D. C.

Sonerud, G. A., and **P. E. Fjeld.** 1987. Long-term memory in egg predators: an experiment with a Hooded Crow. Ornis Scandinavica 18: 323-325.

Sturm, L. 1945. A study of the nesting activities of the American Redstart. Auk 62: 189-206.

Yezerinac, S. M. 1993. American Redstarts using Yellow Warblers' Nests. Wilson Bulletin 105: 529-531.

Received 15 September 2010
Accepted 27 October 2010

Unusual Beaver, *Castor canadensis*, Dams in Central Yukon

THOMAS S. JUNG[1,2], and JENNIFER A. STANIFORTH[1]

[1] Yukon Department of Environment, P.O. Box 2703, Whitehorse, Yukon Y1A 2C6 Canada
[2] Corresponding author. E-mail: thomas.jung@gov.yk.ca

Jung, Thomas S., and Jennifer A. Staniforth. 2010. Unusual Beaver, *Castor canadensis*, dams in central Yukon. Canadian Field-Naturalist 124(3): 274–275.

North American Beavers (*Castor canadensis*) are remarkable for their ability to build dams and modify their habitat. Dams are typically made of the boles and branches of trees and large shrubs, and reinforced with mud and rocks. Here, we report two unusual Beaver dams in central Yukon, Canada, that are made primarily of medium-sized rocks. This observation points to the adaptability of Beavers in using available materials to build their dams.

Key Words: Beaver, *Castor canadensis*, dam construction, Yukon.

One of the more remarkable aspects of the natural history of North American Beavers (*Castor canadensis*) is their ability to alter the landscape through the construction of dams. Dams raise water levels and create reservoirs (Beaver ponds) upstream of the dam, which ensures the entrance to their house is underwater, offers relative protection from terrestrial predators, and provides safe access to terrestrial or cached foods such as willows (*Salix* spp.) and poplars (*Populus* spp.). Beaver dams and ponds have a large impact on the local hydrology (e.g., Woo and Waddington 1990; Gurnell 1998), they alter local ecosystems (Naiman et al. 1986, 1994; Rosell et al. 2005), and they appear to increase local biodiversity (e.g., Wright et al. 2002; Cooke and Zack 2008). As such, Beaver dams are important ecological features in temperate and boreal landscapes and their characterization has received considerable attention (e.g., McComb et al. 1990; Barnes and Mallik 1997).

Typically, Beaver dams are primarily made of wood, including the boles and branches of willows, alders (*Alnus* spp.), and poplars (Doucet et al. 1994; Barnes and Mallik 1996), that Beaver transport by carrying in their mouth. These wooden dams are reinforced with mud and rocks that Beavers transport and put into place with their forepaws. Here, we report unusual Beaver dams found in central Yukon, Canada, that are primarily made of rocks.

On 23 September 2010, we observed three Beaver dams on Swamp Creek, about 72 km north of Beaver Creek, Yukon (62.383°N, 140.876°W), close to the Alaska-Yukon border. The area is the site of an active gold placer mine. Swamp Creek is located in the Klondike Plateau Ecoregion, an area that was unglaciated during the Last Glacial Maximum. Spruce (*Picea mariana*; *P. glauca*) forests, interspersed by stands of Alaskan Birch (*Betula neoalaskana*), Trembling Aspen (*Populus tremuloides*), or Balsam Poplar (*Populus balsamifera*), are the dominant vegetation types at lower elevations. However, placer mining had removed much of the original forest near the creek, allowing for new deciduous growth, and creating settling ponds. The dams were built in an area that was previously mined, downstream of a settling pond in the small creek. The immediate area was dominated by gravel and rock, with some regeneration of willow, alder, and poplar.

Dam A (Figure 1A) was located about 50 m downstream from a settling pond. This dam was about 2.8 m wide and 0.8 m tall and composed of 90% rocks and 10% woody material. The rocks used to build the dam were generally 20-30 cm across, with the larger ones weighing approximately 4-5 kg. A second dam, Dam B (Figure 1B), was located about 32 m upstream from Dam A. This dam was about 5.5 m wide and 1.5 m tall, and composed of about 60% rock and 40% woody material. Dam C was located near another settling pond, about 900 m downstream of Dam A, and was more typical of Beaver dams, being largely composed of woody material with a small amount of mud and rocks.

Two Beaver families lived in the two settling ponds. The surveyed portion of the creek was first occupied by Beavers in 2002, and Dams A and B were built in 2006 by a family of Beavers with kits (K. Warrick, Moosehorn Exploration Ltd., personal communication). This Beaver family may have dispersed from the Beaver family that colonized the settling pond immediately downstream (near Dam C) in 2002. Dams A and B were damaged by a Grizzly Bear (*Ursus arctos*; K. Warrick, Moosehorn Exploration Ltd., personal communication) in 2008, but they were still functional in late 2010.

We are not aware of any other Beaver dams that are made primarily of rocks. Given that the site was an active placer mine, woody vegetation of suitable diameter for building dams was relatively scarce close to the creek, while rocks were plentiful. We believe that the Beavers simply made use of the local building materials in proportion to their availability. Perhaps the Beavers were willing to travel far from the creek for forage, but used materials close to the creek to build their dams. In addition, the available woody vegetation was young and was likely too small to be useful as dam-building material. Alternatively, because willows and Trembling Aspen, favored foods of Beaver (Slough 1978), were not abundant near the creek, per-

FIGURE 1. Photographs taken in 2006 of two Beaver dams made primarily of rocks in central Yukon. Photographs courtesy of Kate and Ian Warrick.

haps the Beavers used rocks to build their dam so that the available woody vegetation could be used for food, rather than dam-building materials. Regardless, we believe that these unique dams are of interest because they point to the adaptability of Beavers in using available materials to build their dams.

Acknowledgments

We are indebted to Kate and Ian Warrick for drawing our attention to these dams, kindly providing detailed information about the Beavers under their stewardship, and allowing access to their placer mining claim. Matt Clarke kindly provided field assistance. We thank Brian Slough for earlier discussions about Beaver. Two anonymous reviewers kindly provided comments on an earlier draft of this note.

Literature Cited

Barnes, D. M., and **A. U. Mallik.** 1996. Use of woody plants in construction of beaver dams in northern Ontario. Canadian Journal of Zoology 9: 1781-1786.

Barnes, D. M., and **A. U. Mallik.** 1997. Habitat factors influencing beaver dam establishment in a northern Ontario watershed. Journal of Wildlife Management 61: 1371-1377.

Cooke, H. A., and **S. Zack.** 2008. Influence of beaver dam density on riparian areas and riparian birds in shrubbsteppe of Wyoming. Western North American Naturalist 68: 365-373.

Doucet, C. M., I. T. Adams, and **J. M. Fryxell.** 1994. Beaver dam and cache composition: are woody species used differently? Ecoscience 1: 268-270.

Gurnell, A. M. 1998. The hydrogeomorphological effects of beaver dam-building activity. Progress in Physical Geography 22: 167-189.

McComb, W. C., J. R. Sedell, and **T. D. Buchholz**. 1990. Dam-site selection by beavers in an eastern Oregon basin. Great Basin Naturalist 50: 273-281.

Naiman, R. J., J. M. Melillo, and **J. E. Hobbie.** 1986. Ecosystem alteration of boreal forest streams by beaver (*Castor canadensis*). Ecology 67: 1254-1269.

Naiman, R. J., G. Pinay, C. A. Johnston, and **J. Pastor.** 1994. Beaver influences on the long-term biogeochemical characteristics of boreal forest drainage networks. Ecology 75: 905-921.

Rosell, F., O. Bozsér, P. Collen, and **H. Parker.** 2005. Ecological impact of beavers *Castor fiber* and *Castor canadensis* and their ability to modify ecosystems. Mammal Review 35: 248-276.

Slough, B. G. 1978. Beaver food cache structure and utilization. Journal of Wildlife Management 42: 644-646.

Woo M.-K., and **J. M. Waddington.** 1990. Effects of beaver dams on subarctic wetland hydrology. Arctic 43: 223-230.

Wright, J. P., C. G. Jones, and **A. S. Flecker.** 2002. An ecosystem engineer, the beaver, increases species richness at the landscape scale. Oecologia 132: 96-101.

Received 1 October 2010
Accepted 20 October 2010

Long Persistence and Other Aspects of Variants of False Mayweed, *Tripleurospermum maritima*, at Sackville, New Brunswick

A. J. ERSKINE

16 Richardson Street, Sackville, New Brunswick E4L 4H6 Canada

Erskine, A. J. 2010. Long persistence and other aspects of variants of False Mayweed, *Tripleurospermum maritima*, at Sackville, New Brunswick. Canadian Field-Naturalist 124(4): 276–277.

Over a 25-year period, plants of *Tripleurospermum maritima* with aberrant inflorescences have been observed growing without cultivation by Crescent Street in Sackville, New Brunswick. Aberrant plants varied between years in locations, suggesting reproduction by seed. Plants with variant inflorescences comprised about one percent of total plants in counted samples. As many as 100 variant plants were found in a year. The site may have received toxic waste disposal causing a mutation that resulted in observed aberrations. The inflorescence aberrations are primarily of two kinds; those with only white rays throughout, and those with some yellow disc flowers that later were concealed by white rays. A third aberration involved inflorescences that appeared nearly normal when first seen, but later developed to the second preceding form. Plants with aberrant inflorescences did not differ from normal plants in morphology or flowering time. Aberrant inflorescences appeared somewhat later in the flowering period than flowering in plants with normal inflorescences.

Key Words: Mayweed, *Tripleurospermum maritima*, *Matricaria maritima*, variant, aberration, New Brunswick.

A False Mayweed (*Tripleurospermum maritima* (L.) W. D. J. Koch, also *Matricaria maritima* L.) with an aberrant inflorescence was first noticed growing without cultivation, near a dumpsite, by Crescent Street in Sackville, New Brunswick, in 1985. Despite broader searches, the only aberrant plants that have been found later are from this area of the town (Erskine 2003a,b). Aberrant plants occurred in the same general areas each year (2003-2009) but were often more than one m apart in successive years, suggesting reproduction by seed rather than by vegetative means. From July-August counted samples, variant plants comprised about one plant in every 100 total plants, thus: 2003 – 18 of 1580; 2005 – 22 of 2000; 2006 – 10 of 850; 2007 – 9 of 850. Variant plants were found (first sightings of individual plants) as early as 9 July (2008) and as late as 25 October (2003,2006). Total variant plants found per year ranged from 28 (2007) to 103 (2008), the largest number following the most drastic disturbance. The site may have received toxic waste disposal causing a mutation that resulted in persisting aberrations not unlike some reported for other Asteraceae (Fambrini et al. 2003).

The inflorescence aberrations are primarily of two kinds; those with only white rays from the start of development (Figure 1, above), and those that had some yellow disc flowers that later became concealed by white rays (not illustrated). A third aberration involved inflorescences that appeared normal at the start, but later developed into the second of the preceding forms (Figure 1, below). There were no obvious differences

FIGURE 1. Above, inflorescences of variant False Mayweeds with only white ray flowers, some occluding the disc and others around the edge of the inflorescence. Photo by Sally Erskine Doucette at Sackville, New Brunswick, 2004. Below, an inflorescence of variant False Mayweed of 3rd type, with many normal disc flowers and a few ray flowers among them, plus normal ray flowers around the edge of the inflorescence. Photo by Thomas Erskine at Sackville, New Brunswick, 2010.

in morphology between normal plants and those with aberrant inflorescences (other than differences in the inflorescences). Flowering time was also similar for both variant and non-variant plants and was apparently governed by disturbance, with plants in recently disturbed habitats flowering earlier. Aberrant inflorescences occurred somewhat later in the flowering period than flowering in plants with normal inflorescences.

Flowering normally begins in early July and aberrant inflorescences begin to appear one to three weeks later.

Additional information on these Mayweed variants at Sackville is available at the National Herbarium of Agriculture and Agri-Food Canada (DAO) in Ottawa or from the author.

Literature Cited

Erskine, A. J. 2003a. Variant Mayweeds (*Matricaria maritima*). New Brunswick Naturalist 30(1): 12-13.

Erskine, A. J. 2003b. More about variant Mayweeds. New Brunsick Naturalist 30(4): 135-136.

Fambrini, M., D. Bertini, and **C. Pugliesi.** 2003. The genetic basis of a mutation that alters the floral symmetry in sunflower. Annals Applied Biology 143: 341-347.

Received 8 September 2010
Accepted 8 December 2010

Book Reviews

Book Review Editor's Note: We are continuing to use the current currency codes. Thus Canadian dollars are CAD, U.S. dollars are USD, Euros are EUR, China Yuan Remimbi are CNY, Australian dollars are AUD and so on.

Zoology

Icelandic Bird Guide

By J. O. Hilmarsson. 2010. Forlagid, Braedraborgarstig 7, Reykjavik, IS – 101, Iceland www.forlagid.is. 672 pages. 4490 Icelandic Kroners, (about 40 CAD)

Iceland is a rocky and rather bare island in the centre of the North Atlantic, but many birds seem to like it a lot, and as this competent and compact bird guide shows us nicely. Iceland's avifauna is located right between the old world, the new world, with the Arctic on top and surrounded by oceans that are affected by the Gulf Stream as well as sea ice. It offers something for everybody and is very informative for the boreal, subarctic, North American and European avifauna. This book helps you to make the sensitive avifauna of Iceland accessible, and which has been a traditional shortcoming for this important region. This great book consists of 24 chapters, such as Introduction, Classification of birds, Glossary, How to use this book, Charts, Distribution maps, Topography of birds, 134 species descriptions (including rare birds), Bird identification, Eggs and young, Birdwatching in Iceland, Bird ringing in Iceland, Statistics on Icelandic birds, Checklist of Icelandic birds, 'Associations, institutions and publications', Sources, List of photographs, Multilingual list of bird names, Index of English names, Index of Latin names, and Notes. I like that three pages with English and Icelandic literature references are provided, which go back to 1936. Bird species names can easily be found in the multilingual list of bird names (Icelandic, Latin, English, N-American, German, Danish, Swedish, Norwegian, Finnish, Dutch, Italian, French and Spanish!). The nation of Iceland features over 345 bird species by now, but not all are covered in this book unfortunately (most breeders, wintering birds, and vagrants are included though). The covered species in this book are classified into six categories (seabirds, waders, gulls and relatives, waterbirds, land or prey birds, and passerines; each section carries a short introductory summary as well). The bird taxonomy goes back to *Birds of North America* (1987) and Sandberg (1992) for Europe; it is probably slightly outdated and not following AviBase (http://avibase.bsc-eoc.org/avibase.jsp) or ITIS (www.itis.org). This bird guide basically does not cover subspecies.

Birding in Iceland is rewarding and offers for instance the only location for easily watching Harlequin Ducks and Barrow's Goldeneyes. The most northern records of breeding Gadwall and Shoveler are found here also. Besides Snowy Owl and Gyrfalcon, fascinating Red Knot and Wheatear migration sightings can be made, and many rare passerine sightings still wait to be documented further, e.g., in the exotic tree plantations and house gardens ('Bicknell's Thrush' and some East European Warblers would make for good birding candidates for instance). Birding in winter and fall also offers many species, e.g., for vagrants. As this book shows us, besides the classic birding hotspots like Lake Myvatn and River Laxa, already the city pond in downtown Reykjavik provides for a great species introduction and bird watching.

This bird guide is very greatly illustrated and offers nice diagrams, maps and over 500 stunning photographs (no drawings are provided; a few rare but elsewhere common species like swifts, martins and warblers could perhaps carry better photos). But I really like that the plumages of gulls and female ducks are presented as special pages. Another real strength of this bird guide is presented with the 25 pages devoted to just eggs and young, and their identification (this will cater for the birding tourists in early summer).

The real strengths of this book are the species chapters and their provided details: occurrence summaries by month, distribution maps, sophisticated diagrams, identification texts, status, size details, and population trends and changes. The data are usually based on 10km and 50km survey grids, Xmas Bird Counts and (British) Wildlife Trust data (raw sources and URLs or contacts are unfortunately not provided).

Additional chapters make for nice, extra and useful information; specifically the section on Icelandic Bird Associations, Institutions and publications I found helpful. The Glossary features 24 terms (one probably could also find them quickly online). The Bird ringing chapter is informative, but a little soft (the Icelandic bird ringing database is not mentioned and no URL is given). Seven pages of 165 photo sources, camera details (and locations!) are given (most photos were taken in the 1990s). Unfortunately, the Checklist of

348 Icelandic birds is based on records from 1998 (over 12 years old); it is available online at www.ni.is/bliki/RCform.pdf.

Another strength of this bird guide are the provided details regarding changes that occurred in the avifauna of Iceland. Such information is otherwise hard to come by, and here bird watchers really can still provide crucial information and updates. Due to man-made global change (global warming) the Dovekie is virtually gone by now from Iceland and as a nesting bird! The Ivory Gull just gets reported as rare visitor (changes for Gyrfalcon, Snowy Owl and Ptarmigan have not been reported, but must be expected to exist). The Icelandic Great Auk extinction story is already part of any good textbook in Conservation and Ornithology; but the Water Rail seems now to follow a similar fate in Iceland (due to Mink predation and wetland drainage). Tufted Ducks invaded Iceland in the 19th century onwards, Short-eared Owls followed in the 20th century, Oystercatchers seem to widen their range. The new occurrence of the Herring Gull and Lesser Black-backed Gull on Iceland is already mentioned since the 1920's. Common Gull, Shoveler and Black-tailed Godwit followed closely (no reasons or explanations are provided by the author for any of these events; one would assume agriculture, hunting regulations and fisheries policies are the drivers). The conservation story of the almost extinct White-tailed Eagle in western Iceland makes for a fascinating detail. But the author has not dealt so well with changes in Northern Gannets and Great Skuas though (both are expanding and/or moving north), or with reporting of fisheries effects on seabirds (perhaps that comes as no bigger surprise to insiders and who know how old-fashioned rural Iceland still is in regards to whaling, hunting of seabirds and dealing with impacts of bad fishing practices). Overall, changes in Iceland's bird world have already been rather dramatic. We are shown that since 1960, three (!) species get added to the Icelandic species list annually, showing major changes in the North Atlantic ecosystems. Ecological issues like Redpoll increases due to Icelandic forest habitat changes are reported in this book too, but urbanization issues and in relation to ravens, house sparrow and starlings are not covered, nor that Iceland is widely overgrazed by sheep and that erosion makes for a serious problem (which affects ground-nesting birds for instance).

Of course, this bird field guide cannot entirely compete with Jonsson's *Bird of Europe*, Sibley's *Guide to Birds* or some data like eBIRD and GBIF (who really can?), but this book makes Icelandic birds much more accessible to us. This field guide by Hilmarsson should be in your hands when dealing with subarctic and Iceland birds species in any capacity.

FALK HUETTMANN

EWHALE lab–Institute of Arctic Biology, Biology & Wildlife Department, University of Alaska-Fairbanks (UAF), Fairbanks Alaska 99775 USA

Birds of the West Indies

Norman Arlott. Princeton University Press, 41 William Street, Princeton, New Jersey, USA 08540-5237 2010. 240 pages. 24.95 USD.

Despite the wide variety of digital tools available for bird identification, Bird Field Guides – in book form – have not yet gone out of style. For years Princeton University Press has been publishing field guides for the identification of birds worldwide. The initial standard field guide usually were a hefty item, not suitable for the average back pocket. Overtime the size has diminished and the quality of the illustrations have been enhanced. In evaluating this new book, I have compared it to 3 other field guides:

Book 2: Peterson's Field Guide. J. Bond. Fifth edition. 1993. Houghton Mifflin Co.

Book 3: H. Raffaele, J. Wiley, O. Garrido, A. Keith and J. Raffaele. 2003. Birds of the West Indies. Princeton University Press.

Book 4: A photographic guide to Birds of Jamaica. A. Sutton, A. Downer, R. Sutton. 2009. Princeton University Press.

Book 1 (book under review) is smaller but slightly heavier than the other Birds of the West Indies Guide (Book 3). The distribution maps are at the back of the book. I see little advantage of book 1 over book 3 in terms of illustrations. Using the drawing of the Scaly-naped Pigeon, I would definitely prefer book 3 in that department. Book 3 has distribution maps with descriptions of the birds. This has much utility when out in the field birding. Book 3 has a list of conservation problems in the front which book 1 does not have. Between book 1 and book 3, the Raffaele et al. book is the preferred choice in terms of usefulness and utility.

When comparing book 1 and book 3 to The Peterson's Guide, they are better than book 2 in terms of illustrations. The only redeeming feature of book 2 is that it has historical value and it is the lightest. However, keep it on your shelf as a collector's item.

I am keeping book 4 – the photographic guide – as the last one for comparison. This book is a field guide to birds in Jamaica – a single country in the West Indies, rather than for all of the islands in this diverse region. Unlike the others, book 4 has colour photographs. The book is exceptionally well illustrated, has range maps on the same page, an excellent overview

in the front on habitat types, distribution, where to go and up to date species lists. It clearly sets a new standard for field guides.

It is always a good idea for the keen birder to have a series of books at one's fingertips. But if space is limiting in your travel bag, I suggest you take along book 3 for general descriptions on the West Indies birds. Let us hope that in the future, Princeton University Press will continue to come up with books for the major islands which can match the standard of book 4.

LU CARBYN

137 Wolf Willow Crescent, Edmonton, Alberta T5T 1T1 Canada

Identifying and Feeding Birds

By Bill Thompson III. 2010. Houghton Mifflin Harcourt Publishing Company. 222 Berkeley Street, Boston, Massachusetts 02116. 246 pages. 14.95 USD, Paper.

Like many naturalists I have several bird feeders in my yard. These attract, on any given day, half a dozen species [e.g., Northern Cardinal] – typical for good feeders in my area. Over the seasons I get an additional 6 or 7 species regularly [e.g., Common Grackle], as the migration comes and goes. Other birds come but are less consistent [Common Redpoll]. Occasionally I see a special bird [Hoary Redpoll]. It took me many years to have such regularly active feeders.

The first step was getting dense bushes a metre or so from the feeder. When I had an open plain for a yard I paid my children to collect all the discarded Christmas trees, and these I piled around my feeder. The next step up was when a friend advised me to have at least one "squirrel-proof" feeder.

I could have saved myself all this frustration if I had owned a copy of this book. The author lays out clearly the different types of feeder, along with their key characteristics [I have four types] He explains the various varieties of food available, their attributes and which birds they attract. The author also discusses bird-friendly [food and shelter] plants in some detail. Woven into the text is advice on pests, non-feeder attractants, myths and cleanliness. He also includes some non-feeder items like bird houses and water features.

The second part of the book is a field guide of 125 selected backyard birds. It uses photographs to portray each bird in its typical plumages. These images are high quality and chosen to show the appropriate identifying points. The accompanying text covers field marks, sounds, habitat and the birds use of backyards. There is a good quality range map for each species.

Any person who follows the advice given by Bill Thompson should have as active a feeder as can be expected in their neighbourhood. The book is thorough, well organised, pleasant to read and attractively illustrated. Is it perfect? I would question some of his choices of birds in the field guide section. For example he includes Turkey Vulture. I know of only one man who staked out agricultural dead stock in his large rural property. He got lots of Ravens and Crows, plus a few buteos and Bald Eagles, but I never saw a vulture at this site. Current health regulations now prohibit this practice.

Thompson also includes birds that I see in my yard [e.g., Robin, both Waxwings], but never at the feeder. In fact many birds are stated "may" visit a feeder [although I doubt it]. Such birds as Robins come for my pond and waterfall or the berry bushes. Perhaps the book would be more accurately titled "Attracting and Identifying Backyard Birds."

Thompson says there are no squirrel-proof feeders and I am inclined to agree. I have three "squirrel-proof" feeders: two are two-sided and one is a single. This last one my wife bought very cheaply at a garage sale this summer. I was delighted as it was in very good condition. It was similar to the two doubles I used with great success in previous years. Imagine my consternation when a vibrantly marked Red Squirrel was able to steal sunflower seeds at will. Then followed two months of squirrel war with various adjustments, modifications and branch trimming. I finally thought I had won, until I saw the local crows feeding in the middle of the road. It was a well-marked, squished squirrel. The other, paler squirrels in my yard have not yet shown the persistence of Mr. Flashy.

The author clearly has a Mid-US bias as his milo story illustrates. He said he published that milo [we call it sorghum] is ignored by birds only to get protests from south-western birders who regularly attracted quail and the like with this seed. I was not surprised then, when he missed out birds like Raven and Hoary Redpoll from his feeder selection. I have seen many Hoary Redpoll here in the Great White North and most of them have been at feeders. I had a house where Ravens were daily visitors and a friend reported a couple of weeks ago [October] getting Ravens here [Ottawa] too. I even had a house where I could induce, with fish remains, Iceland Gulls into my yard – but that is extreme. The author's southern bias also comes through when he discusses feeders. I have four hopper feeders and one is a problem in fall. When it rains during the day and freezes at night the hopper tray and the outlets become solid. For most of the year it is a good feeder, but for a month or so it is a pain. Maybe my wife will buy me a new design hopper for Christmas! The other issue is snow. Some years ago, I put a hopper feeder out in the fall on a pole at

head height. By January it was knee height due to the snow bank. I now have it at almost-too-high-to-reach height and hope it gets no lower than my chest level by mid-winter.

I had a little trouble with the index when I looked up sunflower seed as it is listed as striped or black-oil and not under sunflower.

This book is a must for beginners and anyone setting up in a new location. Following Thompson's logic will allow you to pick a sound plan for your yard. All you will need then is patience and a willingness to adapt to your local situation. It will also be useful to even seasoned feeder watchers and it is a great book to keep by the window. I learned a few new tricks and I have been feeding for 45 years – next spring I will put out crushed eggshells and melon rinds.

ROY JOHN

2193 Emard Crescent, Ottawa, Ontario K1J 6K5 Canada

BOTANY

Freshwater Algae in China

By Wei Yinxin, Hu Hongjun, Science press, Beijing, 2010, 1023 pages, price: 195.00 Yuan RMB.

Algae, or scientifically known as phytoplankton, are the most important primary producers on Earth. It is estimated that the total amount of organic carbon produced through their photosynthesis is approximately seven times that of higher plants. Freshwater algae vary in shape and color, and survive in a large range of freshwater habitats. In these habitats, they are the essential part of the ecosystem and the base of the aquatic food chain. They are not only an important source of food for herbivores, they are also the most important source of atmospheric oxygen given out from their photosynthesis. They can exert profound influence beneficially or detrimentally on the material cycles of natural ecosystems as well as environmental quality.

Owing to the large territory and the varied natural environment of China, the freshwater algae are both abundant and diverse. Nearly a century of investigation has shown that all the categories of freshwater algae occur in China, their variety demonstrated by the nine thousand species recorded. Though China's freshwater algal resources are numerous, because of change to the natural environment (such as drought and other natural disasters) and human activities (especially the accelerated industrialization and urbanization, as well as environmental pollution and water body eutrophication), some rare species have become extinct, or are at the edge of extinction, and harmful algae blooms extensively and frequently occur in many areas of China. In China, the research work on freshwater algae has not been carried out intensively for a long time, and the monograph on the classification and ecology of freshwater algae has long been lacking. This is obviously unfavorable when problems occur and some efficient countermeasures need to be taken. The newly published book *Freshwater Algae in China* timely meets the current and urgent demands to some extent.

In past decades, as fast development and application of science and technology of electron microscopy and modern molecular biology in research area of algae, a large number of new results have been obtained, and the systematic evolution theory and classification system of algae have changed greatly. Thus, a timely summary of these results seems to be very necessary. According to the new results of micro structure observation, photo synthetic pigment composition, ultra structural characteristics and molecular systematics of algae, the book systematically discusses the evolution of algae, and according to the classification system of algae presented, a total of 1572 species, varieties and forms of common fresh water algae which have been found and published in China are included. In addition, a handful of groups and species of algae not been reported presently in China, but widely distribute in other countries and may also exist in China. Some foreign algae species being introduced into China as experimental material have also been included. Morphological traits and habitat characteristics of each taxon are described, together with keys, and one to several figures. The book also briefly discusses the ecology of phytoplankton and water quality monitoring. The main contents of the book are: Geological age, origin of life and the evolution of algae; Cyanophyta; Prochlorophyta; Glaucophyta; Rhodophyta; Chrysophyta; Haptophyta; Xanthophyta; Bacillariophyta; Phaeophyta; Cryptophyta; Dinophyta; Euglenophyta; Chlorophyta; the ecology of phytoplankton and water quality monitoring.

The book is well written with few errors. It can serve as reference for persons who are engaged in botany, phycology, environmental science, algae resources exploitation, environmental protection of surface water and aquaculture.

LI DEZHI[1] and QIN AILI[2]

[1]Lab of Urbanization and Ecological Restoration of Shanghai; National Field Observation and Research Station in Tiantong Forest Ecosystem of Zhejiang; Department of Environmental Science, East China Normal University, 3663, Zhongshan Rd (N). Shanghai, China. 200062.

[2]Shanghai Vocational and Technical College of Agriculture and Forestry, 658 Zhongshan 2 Rd. Songjiang, Shanghai, China. 201600).

ENVIRONMENT

Biological Invasions in China

By Wan Fanghao, Guo Jianying, Zhang Feng. 2010. Science press, Beijing. 312 pages. 180.00 CNY.

An invasive species is a non-indigenous species that crosses a barrier with or without the direct aid of humans, and establishes itself and expands its range on the other side. Biological invasion has become more and more popular, and the aggressive invaders play more and more disastrous effects in virtually all major ecoregions on Earth. Especially in recent years, such events keep rising steeply, since the patterns of global commerce and globalization keep changing fast, resulting in more and more people and goods moving frequently from one place to another, and leading to the breakdown of biogeographic barriers that have historically kept the floras and faunas of different continents separate, and meanwhile the international law regulating the unintentional introduction of harmful alien species through trade is also weak. Global change further exacerbates the biological invasion, implying the proper need of considering the problem in global change scenarios.

Invasive species usually can affect the natural patterns and ecological processes of native species through a variety of direct and indirect mechanisms occurring at genetic, individual, population, and community or ecosystem levels. Bio-invasion is fast becoming one of the world's most costly ecological problems, as it disrupts agriculture, drastically alters ecosystems, spreads disease, and interferes with shipping. Although the full extent and cumulative impact of bio-invasion can only be approximated, it has been regarded as the second worst threat to the ecosystems after habitat destruction. It is regarded as a potent force of global change, contributing to a wide range of deleterious effects including loss of biodiversity, soil erosion, water loss, disease outbreaks, habitat alteration and loss, damaging or decline of native biota and entire landscapes, increased frequency of fires, and shifts in nutrient cycling, jeopardizing endangered species and so on. Invasive species is often referred to as alien "pests" or "weeds" imposing high costs on agriculture, forestry, and causing damage to ecosystems or the environment. Although an invasive species is often defined as an introduced species that has spread widely and caused harm, some species native to a particular area can, under the influence of natural events, increase in numbers and become invasive. Invasive species often coexist with native species for an extended time, and gradually the superior competitive ability of an invasive species becomes apparent as its population grows larger and denser and it adapts to its new location. If the arms races between natives and invaders keep continuing to balance in favour of invaders, and the trend is out of control, a global homogenization of our planetary biota may become the case in the future. Biological invasions will continue to be an ongoing problem in the future given human population growth, its increased needs, and its movement throughout the world. It is time for us to pay more attentions on the ecological impact of biological invasion both at the species and ecosystem levels.

China is a country whose territory spans a vast area and covers diversified types of ecosystems, but for a long time, the problems of biological invasions in China had not become very obvious in the period of self-confinement. Along with implementing an open-door policy for more than 30 years, Chinese economy has increase rapidly, and at mean time, the phenomenon of biological invasion has also become more and more widespread and serious. Having recognized the situation, Chinese ecologists have carried out extensive long-term studies on biological invasions. The newly published comprehensive book *Biological Invasions in China* systematically summarizes the results in this field. Hopefully it will provoke more international attention on the seriousness of the problems of invasive species in China.

The main contents of the book included; Introduction, Chapter 1 Invasive alien species in China: the current status and trends of occurrence; Chapter 2 Occurrence, damage and expansion of major invasive alien species in China; Chapter 3 Extrinsic factors affecting biological invasions in China; Chapter 4 Economic, ecological and social impacts of biological invasions in China; Chapter 5 Development of invasion biology discipline in China; Chapter 6 Progress of basic theoretical research on biological invasions in China; Chapter 7 Progress of applied research on technologies for prevention and management of invasive alien species in China; Chapter 8 Development strategy of the research and management of biological invasions in China; Chapter 9 Demands for innovation research on biological invasions in China.

This book is a timely and essential reference for researchers engaging in biological invasion, biodiversity, ecological safety, animal and plant quarantine, plant protection and environmental protection, and administrative personnel or policy makers in these fields or other related fields.

LI DEZHI[1] and QIN AILI[2]

[1]Lab of Urbanization and Ecological Restoration of Shanghai; National Field Observation and Research Station in Tiantong Forest Ecosystem of Zhejiang; Department of Environmental Science, East China Normal University, 3663, Zhongshan Rd (N). Shanghai, China. 200062;

[2]Shanghai Vocational and Technical College of Agriculture and Forestry, 658 Zhongshan 2 Rd. Songjiang, Shanghai, China. 201600

Desertification and Its Control in China

By Ci Longjun, Yang Xiaohui. Higher Education Press of China, 2010, 513 pages, 89.00Yuan RMB.

The term desertification was first used by Lavauden in 1927; from then on, more than one hundred definitions on desertification have appeared in the literature. The definition of desertification given by the United Nations Convention to Combat Desertification (UNCCD) is the land degradation in arid, semiarid and dry sub-humid areas resulting from various factors, including climatic variations and human activities. Desertification not only reduces the biomass production, but also impairs decomposition process, and even interrupts the circulation of materials and energy flow. Desertification as the changing of productive land into a desert as the result of ruination of land by man-induced soil erosion, has been proceeding worldwide. At present, about more than 100 countries on six continents and one-fifth of the world's total population are affected by desertification. Desertification throughout the world is expanding at an annual rate of 0.5 million km^2. Research has shown that desertification brings harmful environmental effects not only on the area it happens, but also the areas near to and even far away from it. Thus, effective control of desertification and restoration of ecosystem health so as to realize sustainable development has become a urgent and common mission of humanity.

As in the world, desertification is one of the most severe environmental problems in China. China as a developing country with a large population and scarce arable land, feeds 22 percent of the world's population on seven percent of the world's tillable land. However, long term over cultivation has become the most dominant cause for desertification in China. China presently has $262.2*10^4$ km^2 of desertified land and still is increasing at the rate of 2460 km^2 per year. The total area of desertification affected land approximately occupies 27.32% of the total land territory, or 79.1% of the total areas of arid, semi-arid and dry sub-humid areas. In China, desertification affected lands are mainly distributed in the Northwest, North and the Northeast, where some of the most underdeveloped counties are located. Desertification worsens ecological environment, accelerates further poverty and invades the survival space of Chinese people. It is estimated that a populations of 400 million is being threatened by desertification, and the annual direct economic loss caused is approximately 6.5 billion US Dollars. Desertification and desert expansion have become a bottleneck for sustainable development in the dry lands of China.

Different from other books available on the topics of desertification in China, the newly published book *Desertification and Its Control in China* attempts to cover some key topics related to desertification, especially focussed on the desertification pattern and its practical control. The book comprehensively discusses the situation of desertification in China in terms of its formation, distribution, development and prevention and control methods. The book introduced the basic theory and control methods of desertification, especially the numerous results from research carried out for the UN Convention to Combat Desertification, which hopefully will provide some guidelines for prevention and restoration for desertification in China or other areas or countries with similar conditions. The main contents of the book include: 1 Concept and global status of desertification; 2 Natural background of drylands of China; 3 Natural resources and their utilization in the drylands of China; 4 Sandy deserts, Gobi, sandlands and sandified land in dryland; 5 Water erosion in the drylands of China; 6 Soil salinization; 7 Steppe degradation and rehabilitation in Northern China; 8 Biological and technical approaches to control windy desertification; 9 Engineering and technological measures for combating desertification; 10 Optimized sustainable eco-production paradigms in drylands.

This book will become a good reference for the persons who are engaged in research work on desert or desertification, and restoration ecology or ecological engineering, forestry, agriculture and environmental science, etc, as well as teachers and students who major in the relevant fields, or any other persons who are interested in these fields.

LI DEZHI[1] and QIN AILI[2]

[1]Lab of Urbanization and Ecological Restoration of Shanghai; National Field Observation and Research Station in Tiantong Forest Ecosystem of Zhejiang; Department of Environmental Science, East China Normal University, 3663, Zhongshan Rd (N). Shanghai, China. 20006

[2]Shanghai Vocational and Technical College of Agriculture and Forestry, 658 Zhongshan 2 Rd. Songjiang, Shanghai, China. 201600.

Life in the World's Oceans: Diversity, Distribution, and Abundance

Edited by A. D. McIntyre. 2010. Census of Marine Life (COML) and Wiley-Blackwell Publisher, Oxford U.K. Cloth.

This book should be noted by naturalists for many reasons, and for more than the strong Canadian input. It wants to make for "a stepping stone in the process of describing Earth's marine biodiversity and its importance to humanity". The late editor Alasdair McIntyre and his team provides us with a nicely designed, readable and very clean text about the otherwise rather very confusing and widely unknown members of the world's ocean ecosystem. The known and the unknown get described (but unfortunately not much more beyond that). The text of 361 pages packed with world-class information presents a beautiful lay-out, photos, diagrams and maps on the state-of-the-art of many aspects of the world's oceans: a real subject of global crisis and major relevance to mankind. Canadians know this first hand from their own coastal and fisheries experience. The Census of Marine Life (COML) concludes a 10 years research initiative, widely driven by taxonomists and NGOs (e.g., Sloan Foundation, Foundation TOTAL) carrying a huge budget. It fits well into the times of Industrial Globalization and provides a new conceptual template doing science beyond just national views (a great and worldly opportunity, but that was tragically lost again when COML went back some years ago into establishing national/regional nodes). This book reports COML having over 130 participants from the entire world (but many members from Central America, Indonesia, Philippines, Central Africa and similar poor regions are greatly missing; Russia and specifically India and China (!) are widely under-represented). Over 2600 scientists from fourteen teams work on specific research subjects that carry such elusive abbreviations like NAGISA, CReefs, GOMA, POST, COMARGE, CEDAMAR, CMARZ, MARECO, CENSAM, CHESS, ArcOD, CAML, ICOMM, TOPP, OBIS, HMAP and FMAP (for all of their specific and very interesting details I highly encourage the reader to inquire further online and at the great COML website www.coml.org).

The book starts out with a nice and creative Foreword (but which ignores mention of the relevance of a global economy, nature conservation, sustainability and climate change). Virtually endless fascinating highlights and world record datasets can be found in this book of six sections (Oceans Past, Oceans Present-Geographic Realms, Oceans Present-Global Distributions, Oceans Present-Animal Movements, Oceans Future, Using the Data) and 17 chapters. My personal highlights are for instance the sophisticated movement analysis of Pacific Sturgeons, various global GIS data maps of ocean features, fascinating polar and deep sea research, hot vent conservation, global microbe and plankton studies, DNA Bar coding, global profiles of species abundance and diversity, species accumulation curves, chemosynthetic ecosystems, "Direct human intrusions in the deep-sea", and some exciting dispersal maps of sharks, turtles and some seabirds (the general seabird and colony subject is unfortunately widely under-represented in COML). The opening chapter dealing with the History of Marine Animal Populations (HMAP) is truly stunning, but makes for a rather soft read. The digital compilation of over 22 million records covering over 100 000 species in OBIS (www.iobis.org) must represent the COML flagship, and a true world heritage! The World Ocean Registry of Marine Species (WORMS; www.marinespecies.org) is another global (!) mile stone, and many more globally unique data sets are presented! The Yeti Crab (one of the many new species found during COML) has already reached a global celebrity status (but not that its conservation is therefore in any better shape, so far). The book concludes with a six page index.

COML and its workers and publishers must be congratulated indeed; never before in the world history (!) has such an ocean view and detail be presented! It is therefore entirely clear that such a huge global project cannot be without its inherent flaws. I find twelve fundamental problems in this COML project and its summarizing book: the underlying science model, a general lack of even the simplest ecology (e.g., carrying capacity), lack of emphasis on metadata and scientific transparency, lack of relevant statistical methods to derive generalized knowledge, no emphasis on students, wider ignorance of climate change, virtual exclusion of Chinese issues, tolerance of even more economic growth, exclusion of (ocean) ethics, ignorance of the human role and in regards to population growth, a lack of conservation focus, and many smaller but essential conceptual inconsistencies. Despite minute details on taxonomic issues, COML and its book are widely behind on how to derive truly generalized knowledge from such a huge mass of data, and which is usually achieved with the help of modern statistical methods such as non-linear algorithms, data mining and predictive modelling (instead of the linear regressions that are mostly celebrated in this book, if at all. A few Bayesian applications will provide joy though only to the interested. Most of the species distribution and sampling data do <u>not</u> come from a thorough and statistically valid and reviewed research design, do not deal with detectability and auto-correlations, nor correct and test for habitat preferences, build resource selection functions or quantify their patterns (all which makes for the essence of a science-based Adaptive Management, and which is known for well over three decades). But in the Abyssal Marine Life chapter there is a rather interesting bathymetric ecological niche description linked with phylogenetic trees; this avenue should be the future for such type of investigations. Ocean Acidification, Marine Protected Areas (MPAs),

the failed Convention of Biological Diversity (CBD) targets for 2010 and the role of indigenous people are mentioned but usually just in passing, if at all. But even worse, the major problem of our time, CLIMATE CHANGE, got just a very small mention in this 10 years project. Perhaps some taxonomists don't want to be bothered and "just like to count the deckchairs on the Titanic" instead? In that case, they should never be in charge of natural resources and sustainability projects or drive huge and global budgets. It is assumed that with ongoing taxonomic efforts and with its (slow) pace a more complete count of the world's biodiversity could perhaps be available by the year 2250. But where would the needed resources come from, who can wait until then, and should we really pursue that anyways, and while other problems are more pressing? Strategic Conservation Planning holds here the answer, already used for years (a concept that basically was not used by COML nor in this book).

Serious inconsistencies are found in COML and its book: OBIS-SEAMAP www.seamap.env.duke.edu) and SCAR-MARBIN (www.scarmarbin.be) host leading marine webportals and data technology, but together with its co-authors and great programmers (some are easily among the best in the world on this issue) they are almost not mentioned. Co-authorship and project participation rules are a little unclear in this text and appear very hierarchical (e.g., just for granted PIs, but not for all workers and students. For instance, M. Costello authored major publications on Open Access with OBIS but is hardly mentioned in this book; many important ocean scientists and institutions are missing). Readers will find it unclear how other great and accompanying publications from COML match with this book (the Introduction from F. Grassle makes the wider context a little clearer though). Metadata, a hugely discussed item for databases and laboratory work in COML and elsewhere, and a widely recommended assurance for transparent science and decision-making, virtually fell out of the text entirely. Ongoing major initiatives like the International Polar Year (IPY), OOS, GEOSS and GBIF, and even the Rio Convention, are either not mentioned, or compatibilities and overlaps are not discussed or resolved well. But one of the biggest contradictions in COML and its book here can be seen in the TOPP project: public Open Access to all data have been the leading scheme for years in COML and got efficiently promoted with its huge global PR machinery setting a great global role model on public data sharing. However, this subject is suddenly not boldly mentioned in the book any further, and in the TOPP chapter (they just distribute locked-up PDFs, mpgs, etc. instead and apparently to quickly satisfy public data delivery pressures while their own high profile publication writing gets delayed now for a decade). Despite the fact that TOPP mentions to follow Animal Care IACUC requirements from Stanford University etc, such egoistic understandings of animal science simply presents a breach of trust with the entire global community, does not actually serve the animals well, and for a much better and more sophisticated and ongoing review and possible use of the data. Good synergies and intentions are "blocked" and conservation decisions not done for over 10 years now. These issues must not be taken lightly because major institutions and stakeholders are directly involved in COML and participate (e.g., Woods Hole Oceanographic Institution, Rockefeller University, UC Davis, Dalhousie University, NOAA, Forschungsinstitut Senckenberg, Alfred Wegener Institut, Scripps Institution of Oceanography, Rutgers University, Smithsonian Institution, Ifremer).

This book is also surprisingly quiet on global strategic issues with the oceans such as biodiversity copyrights, military applications of mapping and submarine 'hearing devices', territorial and fish stock disputes, a better ocean management and law, institutional failure and liability. "The deep-sea floor is no longer considered a desert". But the lucrative nodule mining section, as well as the widely unregulated fishing issue on sea mounts, must appear somewhat naïve when considering that a global resource conflict is at hand here and that an otherwise very advanced MPA discussion exist already elsewhere (classic MARXAN, SITES and optimization work is nowhere mentioned). It comes as no big surprise that the Norwegian government, Bergen University, once more funds text sections that boldly promote the "continued exploration of the global ridge system" and that New Zealand promotes "Knowledge Transfer to Stakeholders" (=Industry; instead of focussing primarily on a global protection scheme for sustainability). Modern whaling and most oil and offshore gas exploration and shipping issues also are virtually not covered in this book (in a time when Sea Sheppard style conflicts are high on the agenda elsewhere).

So in a peculiar way, COML and its book chooses not to deal with several relevant issues of our time. But this must come as no surprise when private foundations and their financial supporters drive the science, and whose leaders openly promote nuclear energy, quick techno-fixes, a healthy industry, or when they actually represent "Big Oil". The ugly faces of a wrongly understood philanthropy, science and industrial globalization come to bear here. With this book, it's written in stone.

A take-home lesson from this book is that science, just done by NGOs and with much private foundation money, cannot always be in everybody's interest. To better achieve it requires instead a public debate, inclusion of ethics and social science, a truly effective global governance system and considerate decision-making with a global sustainability vision so that everybody benefits (these details are actually fully within the proper definition of science: "For the benefit of the people"). COML's declared "Quantum Leap"

(a term already used up by IPY last years) must therefore remain rather dubious. What is that new knowledge really used for, and by whom, and for what type of management, society, and sustainability?

Even despite the major taxonomic focus in COML, this book further fails to critically review and discuss how subjective, personal, and even widely meaningless some taxonomic and DNA efforts can be and ever have been (e.g., ongoing species disputes for decades to come and just depending on the methods used and the individual researcher), and that it will NOT provide us with relevant sustainability progress any time soon and while we have to handle 9 billion people over the coming 50 years on this earth and its widely over fished oceans. The polar bear (a major marine biodiversity component), it is said, will no sea ice left in just less than 40 years from now; and some southern populations are already gone.

An all-inclusive cost-benefit analysis of COML is still waiting to be done as well as assessing if it all was worthwhile (while the book just states untested: COML surpassed already all expectations). Along these lines, the Canadian-author chapters on FMAP (Future of Marine Animal Populations), supposed to be a modelling project, is disappointing, dangerous even for its ignorance. It just celebrates an old-fashioned (and widely wrong and mechanistic) view that entirely ignores the required pro-active, cumulative and precautionary approach to sustainable management, complexity, economic growth, human population growth, lacking resources and climate change even, but that we would have to fully understand the ocean history first. Thus, it only elaborates on linear synthesis and statistical filter methods, but does not really show any (spatial) future projections or informed ecologically-complete scenarios (but which are widely done elsewhere already for decades and what makes for "good practice"; e.g., in IPCC). That oversight I find scary. Does FMAP really promote "business as usual" and no change in procedure? The Coral Reef (CReefs) chapter is more informative and progressive on that matter, but fails us also by not dealing with the real underlying causes: Promotion of an Global Economic Growth that creates waste, over-consumption, decay of governance structures and climate change.

Despite all the high-tech, data, online efforts and many new findings, this COML book leaves naturalists and the global community here alone with the reality and the future. It still represents an outdated "first world" science view that is widely based on narrow niches, fragmented, and odd and descriptive world views, and with many scientists who either ignore more powerful alternative approaches, do not communicate to each other, or who prefer to marginalise progressive colleagues, wiping others off the agenda and themselves out of budgets. In the year 2010, one must entirely disagree with statements like "For biodiversity research, the strategy must be to first identify a set of indices to assess changes in biodiversity, and make the connections between those changes and potential stressors" (Even IUCN already moved beyond this concept some years ago). By now, we know much better. Time is a critical feature for an achieving Sustainability Management. More traditional research just buys time, does not solve the underlying cause, and keeps explorative issues going, or makes them even stronger. Instead, we must focus on a pro-active sustainability science and which caters predictions and optimizations to assess problems before they occur, and as much as this is still possible to keep mother earth afloat (we are widely out of resources).

We know by now that one must not leave the economy just to the economic scientists; e.g., in so-called elite institutions. And this book shows us that one must not leave the biodiversity to many of such taxonomic and marine-scientist authors neither. With such global science effort summaries, the end of an era, it's now time we and our children head to the safety boats instead and while not much is left in the oceans anymore. We are already widely beyond "peak fish" but still need a Science-based, Pro-active, Sustainable, Steady State Management (These are all terms COML choose not to deal with; Who is to justify this to the next generation?).

FALK HUETTMANN

EWHALE lab – Institute of Arctic Biology, Biology & Wildlife Department, University of Alaska-Fairbanks (UAF), Fairbanks Alaska 99775.

NEW TITLES

Prepared by Roy John

† Available for review * Assigned
Currency Codes – CAD Canadian Dollars, USD U.S. Dollars, EUR Euros, AUD Australian Dollars.

ZOOLOGY

Amphibians and Reptiles of the West Indies: Descriptions, Distributions, and Natural History. By Albert Schwartz and Robert W. Henderson. 2009. University Press, of Florida, 15 NW 15th Street, Gainesville, Florida 32611. 714 pages. 79.95 USD, Cloth.

Guide and Reference to the Amphibians of Western North America (North of Mexico) and Hawaii. By R. D. Bartlett and Patricia P. Bartlett. 2009. University Press of Florida, 15 NW 15th Street, Gainesville, Florida 32611. 256 pages. 29.95 USD, Paper.

Adventures Among Ants: A Global Safari with a Cast of Trillions. By Mark Moffett. 2010 University of California Press, 2120 Berkeley Way, Berkeley, California 94704-1012. 29.95 USD.

Among the Great Apes: Adventures on the Trail of Our Closest Relatives. By Paul Raffaele. 2010. Smithsonian Books, P.O. Box 37012, MRC 513, Capital Gallery, Suite 6001, Washington, DC 20013-7012. 384 pages. 26.99 USD.

Ecological and Behavioral Methods for the Study of Bats. By Thomas H. Kunz. 2009. Johns Hopkins University Press 2715 North Charles Street, Baltimore, Maryland 21218-4363. 100.00 USD.

The Private Lives of Birds: A Scientist Reveals the Intricacies of Avian Social Life. By Bridget Stutchbury. 2010. Walker & Company, 175 Fifth Avenue, New York, New York 10010. 272 pages. 25.00 USD.

*** Identifying and Feeding Birds.** By Bill Thompson III. 2010. Houghton Mifflin Harcourt Publishing Company, 222 Berkeley Street, Boston, Massachusetts 02116. 246 pages. USD, Paper.

Bird Songs Bible: The Complete Illustrated Reference for North American Birds. By Les Beletsky. Chronicle Books/ Cornell Lab of Ornithology's Macaulay Library. 680 Second Street San Francisco, California 94107. 125.00 USD.

Phillipps' Field Guide to the Birds of Borneo: Sabah, Sarawak, Brunei and Kalimantan. By Quentin and Karen Phillipps. John Beaufoy Publishing Limited, 11 Blenheim Court, 316 Woodstock Road , Oxford OX2 7NS, England. 368 pages. 29 EUR.

Birds of Cape May. By Kevin T. Karlson. 2010. Schiffer Publishing, 4880 Lower Valley Road, Atglen, Pennsylvania 19310. 256 pages. 49.99 USD, Cloth.

Birds of the Middle East: Second Edition. By Richard Porter and Simon Aspinall. 2010. Princeton University Press, 41 William Street, Princeton, New Jersey 08540. 400 pages. 39.50 USD Paper.

The Nesting Season: Cuckoos, Cuckolds, and the Invention of Monogamy. By Bernd Heinrich, 2010. Belknap: Harvard University Press 79 Garden Street, Cambridge, Massachusetts 02138. 29.95 USD.

The Star-Crossed Stone: The Secret Life, Myths, and History of a Fascinating Fossil. By Kenneth J. McNamara, 2010. University of Chicago Press, 1427 East 60th Street Chicago, Illinois 60637 272 pages. 27.50 USD, Cloth.

The Rise of Horses: 55 Million Years of Evolution. By Jens Lorenz Franzen. 2010. Johns Hopkins University Press 2715 North Charles Street, Baltimore, Maryland 21218-4363. 65 USD

Insectopedia . By Hugh Raffles.2010. Pantheon [Random House] 1745 Broadway, 3rd Floor, New York, New York 10019. 29.95 USD.

The Wild Mammals of Japan. By S. D. Ohdachi, Y. Ishibashi, M.A. Iwasa and T. Saitih. (Editors). 2010. Shoukadoh Book Sellers. Kyoto, Japan. 544 pages. About 61.73 USD (plus shipping), Cloth.

The Biology of Small Mammals. By Joseph Merritt. 2010. Johns Hopkins University Press, 2715 North Charles Street, Baltimore, Maryland 21218-4363. 60 USD.

Guide and Reference to the Snakes of Western North America (North of Mexico) and Sharks and Rays of Australia; 2nd Edition. By Peter R. Last and John D. Stevens. 2009. CSRIO Publishing, Box 1139, Collingwood Victoria 3066, Australia 644 pages. 100.00 USD, Cloth.

Guide and Reference to the Turtles and Lizards of Western North America (North of Mexico) and Hawaii. By R. D. Bartlett and Patricia P. Bartlett. 2009. University Press of Florida, 15 NW15th Street, Gainesville, Florida 32611. 336 pages. 29.95 USD, Paper.

***Life in a Shell: A Physiologist's View of a Turtle.** By Donald C. Jackson. 2011 Harvard University Press, 79 Garden Street, Cambridge, Massachusetts 02138. 192 pages. 29 USD, Cloth.

The Last Tortoise: A Tale of Extinction in Our Lifetime. Craig Stanford. 2010. Belknap: Harvard University Press, 79 Garden Street, Cambridge, Massachusetts 02138. 210 pages. 23.95 USD, Cloth.

The Whale: In Search of the Giants of the Sea. By Philip Hoare. 2010. Ecco: HarperCollins Harper Collins Publishers Ltd., 1995 Markham Road, Scarborough. 27.99 CAD.

BOTANY

Carnivorous Plants and their Habitats (2 volumes). By Stewart McPherson. 2010. Redfern Natural History Productions. 61 Lake Drive Hamworthy, Poole, Dorset BH15 4LR England, UK. 1442 pages 34.99 GBP each Cloth.

Conifers of the World: The Complete Reference. By James Eckenwalder. 2009. Timber Press, 133 SW 2nd Avenue, Suite 450, Portland, Oregon 97204. 59.95 CAD.

Floral Diagrams: An Aid to Understanding Flower Morphology and Evolution. By Louis P. Ronse de Craene. 2010. Cambridge University Press, 32 Avenue of the Americas, New York, New York 10013-2473. $130 USD.

Flora of North America North of Mexico. Volume 8: Magnoliophyta: Paeoniaceae to Ericaceae. Flora of North America Editorial Committee. 2009. Oxford University Press, 198 Madison Avenue, New York, New York 10016 USA. 95 USD.

Macrolichens of the Pacific Northwest (Second Edition). By Bruce McCune and Linda Geiser. 2009. Oregon State University Press 102 Adams Hall, Corvallis, Oregon 97331. 464 pages. 30.00 USD, Paper.

Trees of Panama and Costa Rica. By Richard Condit, Rolando Pérez & Nefertaris Daguerre 2010.Princeton University Press, 41 William Street, Princeton, New Jersey 08540. 552 pages. Paper 45.00 USD, Cloth 85.00 USD.

ENVIRONMENT

***Assessment of Species Diversity in the Atlantic Maritime Ecozone.** Edited by Donald F. McAlpine and Ian M. Smith. 2010. NRC Press in association with Agriculture and Agri-Food Canada, Environment Canada and the New Brunswick Museum Centre for Biodiversity Research. A Publication of the National Research Council of Canada Monograph Publishing Program, Ottawa, Ontario. 785 pages. 90 CAD.

Hawaii. By R. D. Bartlett and Patricia P. Bartlett. 2009. University Press of Florida, 15 NW 15th Street, Gainesville, Florida 32611. 29.95 USD, Paper.

MISCELLANEOUS

Stolen World: A Tale of Reptiles. Smugglers and Skullduggery. Jennie Erin Smith. 2010. Crown Publishing, [Random House, Inc.] 280 Park Avenue (11-3), New York, New York 10017 336 pages. $25.00 USD.

Leaders in Animal Behavior: The Second Generation. By Lee C. Drickamer. 2010. Cambridge University Press, 32 Avenue of the Americas, New York, New York 10013-2473. 120.99 USD.

Second Nature: The Inner Lives of Animals. Jonathan P. Balcombe. 2010. Palsgrave Macmillan, 175 Fifth Avenue, New York, New York 10010. 27.00 USD.

Conservation Biology for All. By Navjot S. Sodhi and Paul R. Erlich. 2010. Oxford University Press, 198 Madison Avenue, New York, New York 10016 USA. 400 pages. 130.00 USD Cloth.

Emma Darwin: A Victorian Life. By James D. Loy and Kent M. Loy. 2010. University of Press of Florida Press, 15 NW 15th Street, Gainesville, Florida 32611. 448 pages. 39.95 USD.

Multiplicity in Unity: Plant Subindividual Variation and Interactions with Animals. By Carlos M. Herrera. 2009. University of Chicago Press, 1427 East 60th Street Chicago, Illinois 60637 USA. 110 USD.

Looking for a Few Good Males: Female Choice in Evolutionary Biology. By Erika Lorraine Milam. 2010 Johns Hopkins University Press 2715 North Charles Street, Baltimore, Maryland 21218-4363. 60 USD.

RARE USED BOOK

Audubon's Birds of America (the folio edition published between 1827 to 1838) for $10 270 000 USD. With auction fees the total came to $11 500 000 USD! The set went to British art dealer and birder Michael Tollemache.

Minutes of the 131st Annual Business Meeting of the Ottawa Field-Naturalists' Club 12 January 2010

Place and time: Canadian Museum of Nature, Ottawa, Ontario, 7:00 pm
Chairperson: Ken Allison, President

Attendees spent the first half-hour reviewing the minutes of the previous ABM, the Treasurer's report and the OFNC committees' annual reports for 2009. The meeting was called to order at 7:30 pm with some opening remarks from the President.

1. Minutes of the Previous Meeting

It was moved by Ernie Brodo and seconded by David Hobden that the minutes of the 130th Annual Business Meeting be accepted.

Carried

2. Business Arising from the Minutes

There was no business arising from the Minutes.

3. Communications Relating to the Annual Business Meeting

There were no communications relating to the Annual Business Meeting.

4. Treasurer's Report – Frank Pope

Frank began by acknowledging and thanking the volunteers of the Fletcher Wildlife Garden, the editors of Trail & Landscape and the Canadian Field-Naturalist, the OFNC webmaster, members of the Council, trip leaders, the Central Experimental Farm and the Canadian tax payers for their significant contributions to our financial position.

Using three charts, he presented a synopsis of the financial activities of the Club over the last 5 years. The charts covered net assets, total revenue, operating revenue and operating expenses. Net assets, at about $500,000 were about the same as last year. Operating expenses continue to exceed operating income, the difference being made up by donations.

Turning to a two page summary of the operating statements, he noted two significant differences from last year. The first was that we donated $100,000 to the Nature Conservancy last year for the acquisition of the Hewlett-Packard property and this year we donated only $23,500 to the Nature Conservancy for the acquisition of the Wolf Grove property. The other was a surplus from the operation of the Fletcher Wildlife Garden compared to a deficit last year. Expenses were reduced because we did not hire a summer student this year and the June plant sale was very successful. In response to a question about our contribution to the Hewlett-Packard acquisition Frank reported that the Nature Conservancy had told us that we would be recognized by a plaque on the property but he did not know if it had been installed yet. **ACTION:** Frank to follow up with the Nature Conservancy of Canada.

As an introduction to the auditor's report, Frank explained that the auditor was now required to include donations as operating income and this makes the financial statements less useful to us. Another change this year has been the installation of Simply Accounting for our financial records. He thanked Ann MacKenzie and Jim Ward for their efforts in this regard. Given these changes, he said that, were there a member of the Club with accounting experience and a little time, he could use some help.

He then went through the financial statements page by page. In response to a question about the $3,977 remaining in the Alfred Bog account he said that it was time to close it out. Two or three properties in the bog remain in private hands and when they come onto the market our contribution would be insignificant. We are looking for some other way that this money can be used in the bog. A contribution of $1 for every purchase of the book "Lichens of North America" should have been added to the Alfred Bog account but it does not show up in the financial statements. Frank said that this was an oversight.

Concern was expressed from the floor about the delay in publishing the Canadian Field-Naturalist which is currently running 18 months behind schedule. Is this discouraging prospective authors? One suggestion was to publish issues 1 and 2 in one volume, and then issue 3 and 4 in the next. Frank explained that the Publications Committee is working on a new business plan to try to improve the situation. He added that recently we have started to post complete issues on the website but we need to find some way to cover the costs.

It was moved by Frank Pope that this financial statement be accepted as a fair representation of the financial position of the Club as of September 30 2009.

Seconded by David Hobden.

Carried

5. Committee Reports

Ken Allison asked for questions and comments on the 2009 Committee reports which had been distributed to the attendees.

Moved by Diane Kitching and seconded by Jeff Skevington that the reports be accepted as presented.

Eleanor Zurbrigg asked if the reprints would be uniformly formatted before they are printed in the CFN. Diane Kitching added to the motion that the reports be published in a uniform format in the CFN.

Carried

6. Nomination of the Auditor

Moved by Frank Pope and seconded by Ann MacKenzie that Janet Gehr continues as Auditor for another year.

Carried

7. Report of the Nominating Committee– Fenja Brodo

SLATE PROPOSED BY THE NOMINATING COMMITTEE

Officers

President	Ann MacKenzie
1st Vice President	Fenja Brodo
2nd Vice President	Jeff Skevington
Recording Secretary	Annie Bélair
Treasurer	Frank Pope

Ex-officio members

Past President	Ken Allison
Administrator	Frank Pope
Editor CFN	Francis Cook
Editor T&L	Karen McLachlan Hamilton
ON Nature Rep	Diane Lepage

Committee Chairs

Awards	Eleanor Zurbrigg
Birds	Chris Traynor
Conservation	Stan Rosenbaum
Education & Publicity	vacant
Excursions and Lectures	Christine Wong
Executive	Ann MacKenzie
Finance	Ann MacKenzie
Fletcher Wildlife Garden	Sandra Garland
Macoun Club	see below
Membership	Henry Steger
Publications	Ron Bedford

Members at large

Barbara Chouinard
Julia Cipriani
David Hobden
Diane Kitching (Macoun rep)
Luke Periard

Chairs not on Council

Macoun: Rob Lee

Gillian Marston who is stepping doing from her role as chair of the Education and Publicity Committee, be thanked for her services to the Club.

Ann MacKenzie thanked everyone for electing her as president and commented that she felt the enormity of the task after attending Dan Brunton's presentation on the OFNC's 130th anniversary in December. She invited everyone to contact her with ideas or comments.

Moved by Fenja Brodo and seconded by Frank Pope that the above slate be accepted as members of the Council of the OFNC for 2010.

Carried

8. New Business

After the mention of Dan Brunton's presentation on the OFNC's 130th anniversary in December, there was a discussion about making the speaker's talk available to everyone. One suggestion was to put the speakers' presentation, or a copy of his CFN article on the 125th anniversary on the OFNC website. A more general suggestion was that major talks, like Dan Brunton's, could be video-taped and put on the website.

9. Adjournment

Moved by Ernie Brodo and seconded by Fenja Brodo that the meeting be adjourned at 8:50 pm.

Carried

ANNIE BÉLAIR

The Ottawa Field-Naturalists' Club 2009 Annual Reports

Awards Committee Annual Report – 2009

The Awards Committee met once in 2009 to select recipients of the Club's seven awards. Committee members prepared the citations for each recipient which outline the many ways in which the person had distinguished herself or himself by accomplishments in the field of natural history and conservation, or by extraordinary activity within the Club. The awards were presented at the Club's annual Soiree in April.

ELEANOR ZURBRIGG, CHAIR

Birds Committee Annual Report – 2009

The Birds Committee organized the Fall Bird Count and the Dunrobin Christmas Bird Count. With the Club des Ornithologues they organized the Christmas Bird Count. All events were well attended. The committee was again successful in another Peregrine Falcon Watch at the downtown nest site. The Bird Record Sub-committee is involved in an ongoing and detailed database of all Ottawa bird records. This sub-committee also met several times to review rare bird records. The seed-a-thon was supplied the funds to operate the

club feeders through another winter. The committee continues to operate both a status line of regional bird reports and a rare bird alert. This past year also saw the installation of 15 nest boxes for Eastern Screech Owls. The committee also provided trip leaders for club excursions and bird related articles for Trail and Landscape.

CHRIS TRAYNOR, CHAIR

Conservation Annual Report – 2009

The committee worked substantially on a single project during 2009, namely as active participants with the Greenbelt Coalition on the current NCC review of the 1996 Greenbelt Master Plan. GREENBELT COALITION – The coalition convened for meetings on March 9, April 7, May 19, and November 9. Stan Rosenbaum and Ken Young of OFNC, along with four other coalition members, contributed material for a position paper, and Stan compiled the material into a single document. After providing a background and historical summary, the current draft 5 identifies Greenbelt benefits (values) as aesthetic, public ownership, environmental, agricultural, lifestyle and recreational. It also presents a number of issues, listed as built facilities, intensification (in the city), infrastructure, long-term issues, and legal protection of Greenbelt lands. Draft 5 was reviewed favourably at the November 9 meeting, with a few minor changes. Among these, in May, the NCC review team had invited the coalition to offer answers to three questions, as below. Our first attempt at answering them follows each question:

1. How might the Greenbelt become an environmental showcase for the Nation's Capital? Recommendation: Retain undeveloped land free from development. Increasing contrast between natural spaces and surrounding urbanization will automatically enhance the Greenbelt as an environmental showcase.
2. Are there other ecological values that we should consider as part of the assessment of Greenbelt existing conditions? Recommendation: Recognize the high ecological values of agricultural lands, if they are managed with this in mind, as discussed in Section 2.4.
3. Where might there be opportunities to strengthen the Greenbelt's ecological features and functions? Recommendation: Certain contiguous former Greenbelt lands should be re-integrated into the Greenbelt in order to protect their and the current Greenbelt's ecological functions.

However, at the November meeting it was decided that our responses to these questions should be expressed in more detail. NCC is inviting coalition members to a 2-day Visioning Workshop on November 25-26, aimed at looking ahead up to 50 years into the future of the Greenbelt. My view on this is already captured in this excerpt from our draft 5 document: "While crystal-ball gazing of this type carries many uncertainties, the least likely future is that the present pattern remains unchanged. Planning for an unknown future is best approached by keeping options open, which means retaining public ownership of all Greenbelt land, and refraining from erecting built infrastructure upon it."

STAN ROSENBAUM, CHAIR

Excursions and Lectures Committee Annual Report – 2009

We had a successful year with 32 trips and one work shop, our ten monthly meetings, the Soirée plus an additional talk at the Fletcher Wildlife Garden Interpretation Centre. This year two excursions were cancelled due to bad weather. Our Soirée was a much abbreviated evening because of a freak storm that caused a power outage at St. Basil's Church. Two of our monthly meetings were held at the Neatby Building, Carling Avenue while the CMN was renovating the VMMB.

Birding is the most popular activity, with 16 trips organized in 2009. We need to entice more leaders to lead more birding trips. Our six full-day excursions were well attended. We had two trips that involved canoes, allowable thanks to a change in our insurance. For one canoe trip we partnered with the South Nation Conservation Authority. This was the third year that we participated in the North American Butterfly Count. Other trips emphasized geology, mosses, lichens, botany, general natural history.

This year we added two events specifically for families and propose to include more such trips.

We need to publicize our monthly talks and plan to do that when we move into our new quarters in June 2010.

FENJA BRODO, CHAIR

Fletcher Wildlife Garden Annual Report – 2009

Habitat improvements – In early spring, we installed a turtle raft in the deep end of our Amphibian Pond. It was well used over the summer by painted and Blandings turtles as well as ducks. In the Backyard Garden, we created a wet area next to the pond, where we planted blue flags, boneset, Joe-Pye weed, swamp milkweed and other wetland species. The Butterfly Meadow was expanded once again. Agriculture and Agri-Foods Canada was kind enough to rototill the new area in both spring and fall; it will be planted in 2010.

Fundraising – Our annual native plant sale was a huge success this year, thanks to a committee of energetic and creative volunteers. We took in over $4000 on the day of the sale and about $800 the following week. We received donations of native plants from a number of people and we sold plants to many regular customers and people who are involved in community garden projects in various parts of the city.

Outreach – We produced four newsletters and our mailing list continues to grow. Our photo galleries on pbase.com are well used and enjoyed, with over 100,000 page views.

We once again participated in the National Capital Wildlife Festival: as a sponsor, as a participant in the "fair" at Billing Bridge Shopping Centre, and as co-organizers of the annual forum. We also led two well-attended guided walks at the FWG.

External Relations – A Price WaterhouseCoopers Green Team spent a Friday at the FWG planting cedar trees in the ravine, where buckthorn trees were removed in 2008. One of our volunteers brought a group of junior high school students to help the Friday volunteers in a number of tasks.

Although several bonfires were set in spring, we were able to solve this problem by spreading pig manure donated by AAFC. AAFC also repaired the ceilings in our interpretive centre and painted the new ceilings and the bathroom.

SANDY GARLAND, CHAIR

Macoun Club Committee Annual Report – 2009

The Committee met once at the beginning of the year to plan for the year, and thereafter handled the month-by-month planning by telephone and e-mail. Committee members supervised or gave presentations at 18 indoor meetings, and led 18 field trips (including 4 special field trips in the summer). Meetings were held at the Fletcher Wildlife Garden, and most

field trips took place either in the Club's nature study area in Ottawa's western Greenbelt, or on what was the late Mary Stuart's land in the Pakenham Hills. One trip was devoted to a bioblitz of a natural city park, with the results being provided to the local community association.

For five years now there has been no high-school-age group, but both younger groups (ages 8-11 and 12-14) were strong and active.

The Club program is outlined in a monthly newsletter and online, and members and leaders

write and draw for The Little Bear, which is published annually.

ROBERT E. LEE, CHAIR

Publications Committee Annual Report – 2009

The Publications Committee met three times in 2009.

Three issues of *The Canadian Field-Naturalist* were published in 2009: Volume **121** (4) and Volume **122** (1,2). These three issues contained 318 pages; 27 articles; 23 notes; 34 book reviews; 84 new titles; 1 commemorative tribute; 13 pages of News and Comment; 2 pages of miscellany; and a 21 page index. In these three issues and in Volume **121** (3) (not reported a year ago) Manning fund interest supported 12 papers for a total of $3950.

The online version of *The Canadian Field-Naturalist* is essentially ready to go. A notice of this will appear on the OFNC website and in *T&L*. Also, as publicity for current and hopefully new subscribers, the current issue will be posted for free to all. Some administrative details have still to be finalized for issuing passwords and tracking those registering for the electronic version. A number of online providers have requested permission to post *The CFN* on their websites, citing the advantages of wider visibility and revenue to *The OFNC*. An ad hoc subcommittee was set up (E. Morton, chair; J. Fitzsimmons; S. Garland) to investigate the financial aspects of such postings and of online publication costs in general.

Volume **43** of *Trail & Landscape* was published in four issues containing 184 pages. The 20-year index for Volumes **21-40** is available on the *OFNC* website and on a CD for a small fee. Hard copies have not yet been printed. In May the long-time printer, Lomor, went out of business. Fortunately, a possible crisis was avoided when former Lomor employees took over the printing of *Trail* &Landscape.

RONALD E. BEDFORD, CHAIR

Finance Committee Annual Report – 2009

The Finance Committee met twice during the year, March 30 and August 19 as well as internet communication throughout the year. Highlights include:

1. Barbara Chouinard joined the Committee in March.
2. Considerable effort went to ensuring that the new accounting software, Simply Accounting, was working effectively for the Club.
3. Committee Chairs will be receiving regular reports. The first report will be after the budget is set in October. At that time they will get a detailed listing of the past years financial entries as well as the budget for the upcoming year. The second will be a mid-year report, about March. The third report will be late June or early July to help committees determine their budget needs for the next fiscal year.
4. The Finance Committee agreed to the donation of $23,000 to the Nature Conservancy for the Wolf Grove land purchase. At the same time, Finance Committee advised Council that this should be the last major expenditure until there is a turn-around in the financial situation of the Club.
5. A proposed budget for 2009-2010 was developed and submitted to Council. A deficit of about $17,000 was forecast.

ANN MACKENZIE, CHAIR

Membership Committee Annual Report – 2009

The distribution of the membership for 2009 at September 30, 2009* is shown in the table below, with the corresponding numbers for 2008 in brackets. "Others" represent, for the greatest part, affiliate organizations that receive complimentary copies of the Club's publications. Local membership (within 50 km of Parliament Hill) was 660 and 620 in 2008 and 2009, respectively. The reduction of 46 in total membership is greater than experienced in each of the last three years. The continuing decrease in membership presents a challenge for the Club, particularly since all but one of the reductions are attributable to a decrease in local membership.

H. STEGER, CHAIR

	CANADIAN		USA		OTHER		TOTAL	
Individual	376	(400)	17	(16)	1	(3)	394	(419)
Family	279	(301)	1	(1)	1	(1)	281	(303)
Sustaining	15	(17)	0	(0)	0	(0)	15	(17)
T and L	4	(3)	0	(0)	0	(0)	4	(3)
Honorary	20	(21)	0	(0)	0	(0)	20	(21)
Life	52	(47)	5	(5)	1	(1)	58	(53)
Other	24	(26)	1	(1)	1	(1)	26	(28)
TOTAL	770	815	24	(23)	4	(6)	798	(844)

* The membership distribution for this report is for the Club's fiscal year (October 1 to September 30 of the next year) for both 2009 and 2008. For previous reports, the time period was August 1 to July 31 of the next year.

Auditor's Report

To The Members of THE OTTAWA FIELD NATURALISTS' CLUB

I have audited the statement of financial position of THE OTTAWA FIELD-NATURALISTS' CLUB as at September 30, 2009, the statement of changes in net assets, the statement of operations, and the statement of cash flows for the year then ended. These financial statements are the responsibility of the organization's management. My responsibility is to express an opinion on these financial statements based on my audit.

Except as explained in the following paragraph, I conducted my audit in accordance with Canadian generally accepted auditing standards. Those standards require that I plan and perform an audit to obtain reasonable assurance whether the financial statements are free of material misstatement. An audit includes examining, on a test basis, evidence supporting the amounts and disclosures in the financial statements. An audit also includes assessing the accounting principles used and significant estimates made by management, as well as evaluating the overall financial statement presentation.

In common with many non-profit organizations, THE OTTAWA FIELD-NATURALISTS' CLUB derives some of its revenue from donations and fundraising activities. These revenues are not readily susceptible to complete audit verification. Accordingly, my verification of these revenues was limited to the amounts recorded in the records of THE OTTAWA FIELD-NATURALISTS' CLUB, and I was not able to determine whether any adjustments to the recorded amounts might be necessary.

In my opinion, except for the effects of adjustments, if any, which I might have determined to be necessary had I been able to satisfy myself concerning the completeness of the revenue referred to in the preceding paragraph, these financial statements present fairly, in all material respects, the financial position of the organization as at September 30, 2009, and the results of its operations and cash flows for the year then ended in accordance with Canadian generally accepted accounting principles.

JANET M. GEHR
C.A., Licensed Public Accountant

North Gower, ON
January 11, 2010

The Ottawa Field-Naturalists' Club
Balance Sheet
September 30, 2009

	2009	2008
ASSETS		
CURRENT		
Cash	$84,901	$35,571
Prepaid Expenses	3,435	0
Investment certificate (Note 1)	104,833	140,688
Marketable securities (Note 2)	50,913	19,992
Accounts receivable	791	17,815
	244,873	214,066
LAND – ALFRED BOG (At cost, assessed value $19,100)	3,348	3,348
Marketable Securities (Note 2)	281,300	306,308
	$529,521	$523,722
LIABILITIES AND FUND BALANCES		
CURRENT		
Accounts payable and accrued liabilities	$2,500	$4,684
Deferred revenue	9,987	12,901
	12,487	17,585
LIFE MEMBERSHIPS	18,744	16,876
NET ASSETS		
Unrestricted	258,062	248,084
Internally restricted	240,228	241,177
	498,290	489,261
	$529,521	$523,722

The Ottawa Field-Naturalists' Club
Statement of Operations
For the year ended September 30, 2009

	2009	2008
REVENUE		
Memberships	$23,547	$24,554
Donations	17,686	43,444
Interest	19,050	22,148
GST rebate	2,666	4,038
Sales	437	3,432
Other	1,437	200
	64,823	97,816
OPERATING EXPENSES		
Administrator	2,000	2,000
Affiliation fees	627	1,060
Computer expense	5,967	2,252
Membership committee	1,033	1,060
Donations	23,500	101,000
Bookkeeper	6,300	6,300
Telephone	2,729	1,874
Insurance	770	694
Office	986	627
Postage	666	226
Professional fees	2,000	2,000
GST	3,357	4,343
Other	1,815	3,206
	51,750	126,642
ACTIVITY EXPENSES		
Awards	377	497
Birds	1,681	1,826
Canadian Field-Naturalist (Note 3)	8,946	13,863
Education and publicity	1,109	1,153
Excursions and lectures	429	(708)
Macoun Field Club	599	416
Trail and Landscape	9,810	10,815
Fletcher Wildlife Garden (Note 4)	(2,925)	3,419
	20,026	31,281
	71,776	157,923
EXCESS EXPENSES	$ (6,953)	($60,107)

The Ottawa Field-Naturalists' Club
Statement of Cash Flows
For the year ended September 30, 2009

	2009	2008
Cash Flows from Operating Activities		
Excess (expenditures) revenue for the year	($6,953)	($60,107)
Net change in non-cash balances	24,473	(15,612)
(Decrease) in Cash from Operating Activities	17,520	(75,719)
Cash Flows From Financing and Investing Activities		
Increase in Life Memberships	1,868	1,865
Net purchase and sale of investments	(5,913)	2,425
	(4,045)	4,290
Net (Decrease) Increase in Cash and GIC	13,475	(71,429)
Cash and GIC, beginning of year	176,259	247,688
Cash and GIC, end of year	$189,734	$176,259
Net Change in Non-Cash Balances		
Accounts receivable	$17,024	($9,878)
Cumulative unrealized losses on financial assets	15,982	(12,888)
Prepaid expenses	(3,435)	0
Accounts payable and accrued liabilities	(2,184)	1,588
Deferred revenue	(2,914)	5,566
	$24,473	($15,612)

The Ottawa Field-Naturalists' Club Notes to the Financial Statements
For the year ended September 30, 2009

	2009	2008
1. CASH(Note 2, Accounting Policies)		
Chequing	$ 19,106	$ 8,225
Savings	52,682	19,561
Nesbitt Burns	4,338	5,914
Fletcher Wildlife Garden	8,775	1,871
	$ 84,902	$ 35,571

Maturity Value	Maturity Date	Yield	Market Value
$ 77,715	09/29/10	.65%	$77,715
26,000	10/09/12	4.41%	27,118
			$ 104,833

2. MARKETABLE SECURITIES (Note 2, Accounting Policies)

	Maturity Value	Maturity Date	Yield	Market Value
Prov. of Newfoundland Bond	20,000	10/07/08	6.263%	$ 19,992
Gov. of Canada Coupon	30,167	12/01/09	5.605%	29,199
Prov. of New Brunswick Bond	20,000	06/15/10	6.231%	20,937
Prov. of Newfoundland Coupon	44,782	10/17/11	4.525%	39,970
Prov. of Ontario Coupon	15,376	12/02/12	4.591%	13,040
Prov. of Manitoba Coupon	45,740	09/05/13	4.694%	37,316
Prov. of New Brunswick Bond	60,000	12/03/15	3.965%	59,405
Res CIBC Int BB6	70,827	10/31/14	4.144%	49,597
Ontario Hydro	28,281	11/26/16	4.791%	19,519
Prov. of Ontario Coupon	30,000	12/02/17	5.000%	37,325
				$326,300

3. Canadian Field Naturalist Operations

	2009	2008
REVENUE		
Subscriptions	$15,400	$21,483
Reprints	2,411	2,909
Publication charges	27,086	36,419
Other	0	2,178
	44,897	62,989
EXPENSES		
Publishing	29,245	44,731
Reprints	1,200	1,940
Circulation	7,899	9,402
Editing	9,934	15,365
Other	0	132
	48,278	71,570
Excess Expenses Over Revenue	($3,381)	($8,581)

The Ottawa Field-Naturalists' Club Notes to the Financial Statements
For the year ended September 30, 2009

4. Fletcher Wildlife Garden

	2009	2008
REVENUE		
Human Resources and Skills Dev. Canada	–	$1,838
City of Ottawa, water testing	0	1,125
City of Ottawa, buckthorn removal	0	7,875
Sales and other income	5,774	2,714
GST refund	0	119
Donations	400	1,135
	6,174	14,806
EXPENSES		
Program	89	5,385
Backyard	765	530
Buckthorn removal	0	7,800
Habitats	817	1,857
Interpretation centre	980	219
Administration	201	461
GST	27	550
Fund raising	219	212
Publications	70	46
Pond testing	0	1,140
Library	81	25
	3,249	18,225
Excess Expenses Over Revenue	$2,925	($3,419)

5. Statement of Fund Operations and Changes in Net Assets

	General Reserve	Manning	Seedathon	Anne Hanes Memorial	De Kiriline Lawrence	Macoun Baillie	Alfred Bog	Total
Revenue								
Donations	$ 0	$ 0	$ 919	$ 0	$ 5	$ 0	$ 0	$ 924
Interest	0	4,682	0	0	0	0	0	4,682
Sales	0	0	0	0	326	0	0	326
	0	4,682	919	0	331	0	0	5,932
Expenses								
Waived charges, CFN	0	5,565	0	0	0	0	0	5,565
Seed	0	0	1,200	0	0	0	0	1,200
Prints	0	0	0	116	0	0	0	116
	0	5,565	1,200	116	0	0	0	6,881
Net Revenue (Expenses)	0	(883)	(281)	(116)	331	0	0	(949)
Net Assets, Beginning of Year	100,000	121,827	690	746	12,733	1,204	3,977	241,177
Net Assets, End of Year	$100,000	$120,944	$409	$630	$13,064	$1,204	$3,977	$240,228

6. Publication Liability

A subscription entitles the subscriber to four issues of The Canadian Field-Naturalist based on a calender year. As the year end of the Club is September 30, the Club incurs a liability for publishing the fourth issue of each publication.

At this time, however, the publication of The Canadian Field-Naturalist is running late. At September 30, 2009, the Club owes subscribers Vol. 2, 3, and 4 of 2008. Although most of the work preparing theses publications are done by volunteers, the Club must pay for printing and mailing. Based upon recent costs, it is estimated that the Club has a liability of $45,000 for the outstanding issues. This amount will be reduced by page charges to the authors in the amount of 40% of the printing costs.

7. Donations

During the year the Club donated $23,000 to the Nature Conservancy of Canada toward the successful acquisition of the Wolf Grove natural area.

The Ottawa Field-Naturalists' Club Summary of Significant Accounting Policies

1. Purpose of the Organization

The organization is non-profit and incorporated under the laws of Ontario (1884). As a non-profit organization, it is not subject to income taxes under the Income Tax Act. The organization promotes the appreciation, preservation, and conservation of Canada's natural heritage. It encourages investigation and publishes the results of the research in all fields of natural history and diffuses information on these fields as widely as possible. It also supports and cooperates with other organizations engaging in preserving, maintaining or restoring environments of high quality for living things.

2. Financial Instruments

Financial assets and liabilities are recognized and measured as follows:

- Cash, consisting of bank and broker account balances, and short-term investment certificates (GIC's due within one year) are classified as a held-for-trading financial asset, measured at fair value and changes in fair value are recognized in the statement of operations.
- Trade accounts receivable are classified as loans and receivables, and measured at amortized cost. In this case the value is at the same amount as originally recorded.
- Marketable securities and investments are classified as available-for-sale investments. They are recognized at fair value and changes in this value are recognized in the statement of changes in net assets until they are sold. When investments are sold the related accumulated gain or loss are recognized in the statement of operations. Any transaction costs are added to the initial cost of the investment.
- Accounts payable and accrued liabilities are classified as other financial liabilities. They are measured at amortized cost using the effective interest method.

3. Financial risk management objectives and policies

The Club is exposed to various financial risks resulting from both it's operations and it's investment activities. The Club's management manages financial risks and focuses on actively guaranteeing the Club's short- and medium-term cash flows by minimizing its exposure to capital markets.

The carrying amount of the Club's financial assets on the statement of financial position represents the maximum amount exposed to credit risk. This credit risk is primarily attributed to the accounts receivable. The Club does not require a credit check or guarantee from its members. The accounts receivable are limited to small transactions for memberships and subscriptions, with the occasional larger one for articles.

The Club's objectives to managing capital are to safeguard the Club's ability to continue as a going concern and to meet it's financial obligations. It meets these objectives by investing in secure obligations and guaranteed investment certificates that mature at various intervals.

4. Capital Assets

Capital assets in excess of $4,000 cost are recorded as assets at cost and amortized on a straight-line basis. These assets have been fully amortized.

5. Funds and Revenue Recognition

The organization prepares it's financial statements using fund accounting. All funds are internally restricted. The purpose of the internally restricted funds are as follows:

- General Reserve – this amount was established by the Board to fund outstanding operating expenses when the Club is terminated.
- Manning – this fund was established by a bequest, and the interest generated is used to assist authors to publish articles in the Canadian Field-Naturalist (80%), and for special Club projects (20%).
- Seedathon – this fund collects donations from the annual bird sighting event and purchases seed for the Clubs bird feeders.
- Anne Hanes Memorial – this fund was raised in memory of Anne Hanes, the founding editor of Trail and Landscape, and is used to finance the annual winners of the Anne Hanes Natural History Award.
- de Kiriline-Lawrence – this was funded by a bequest from the popular author of nature books, and is supplemented by annual donations and used to support conservation efforts.
- Macoun Baillie Birdathon – this fund recognizes the donations and pledges based upon the number of bird sightings in the one day birdathon sponsored by Bird Studies Canada, and is used to support the Macoun Field Club, a club for youth.
- Alfred Bog – a fund established to raise funds for the successful acquisition of Alfred Bog property, and to continue to raise money for purchase of the remaining property in the Bog.

Membership fees and subscriptions are recognized in the year to which they apply. Life memberships are written off over 15 years.

Donations, and all other fund-raising revenue is recognized when received. GST refunds are recognized when received.

Realized gains and losses are reported in the statement of operations, while unrealized gains and losses are reported in the statement of changes in net assets.

6. Foreign Currency

Transactions during the year in US dollars have been converted in the accounts to Canadian dollars at the exchange rate effective at the date of the transaction. All monetary assets in US dollars at year end have been converted to Canadian dollars at the rate effective on Sept. 30, 2008. Gains or losses resulting therefrom are included in revenue or expenses.

7. Accounting Estimates

The preparation of financial statements in accordance with Canadian generally accepted accounting principles requires management to make estimates and assumptions that effect the amounts recorded in the financial statements and notes to the financial statements. These estimates are based on management's best knowledge of current events and actions that the Club may take in the future. Actual results may differ from these estimates.

8. Comparative Figures

Certain comparative figures have been reclassified to conform with the presentation adopted in the current year.

9. Future Accounting Standards

In September 2008, the Canadian Institute of Chartered Accountants (CICA) modified the accounting standards that apply only to not-for-profit organizations. Changes that would affect the Club are:

- Revenue and expenses must be recognized and presented on a gross basis when an organization is acting as a principal in transactions;
- New disclosures are applicable when the organization classifies its expenses by function.

These new standards are effective for fiscal years beginning after January 1, 2009, and would apply to the next fiscal year of the Club.

Errata for The Canadian Field-Naturalist 124(1) and 124(2)

Erratum 124(1): 97

The January-March 2010, Volume 124, Number 1 issue of *The Canadian Field-Naturalist*. In a brief notice on page 97, News and Comment, re Hue MacKenzie's death; the death date is incorrect. It should be 9 November 2009, not December. Also, the retirement location is given as "…South Surry, Vancouver, British Columbia…" It should read "Surrey, British Columbia..." perhaps with some reference to Surrey being a suburb of Vancouver. The location as shown in the death notice doesn't exist.

JO ANN MACKENZIE

Erratum 124(2): 113, 115, 117

In authors' line on 113 the last author "Powers" should be "Power". The error is repeated in the citation strip on the same page and in the headers on subsequent uneven numbered pages (115, 117).

Erratum 124(2): 119, 121

In headers on pages 119 and 121 "Keven" should be "Kevan".

Erratum 124(2): 196

In notice of Brenda Carter's death, the date of Tom Manning's passing should be 1998 not 1968.

DAN BRUNTON

Erratum 124(2): 102

Corrected map in lead paper by Gilhen

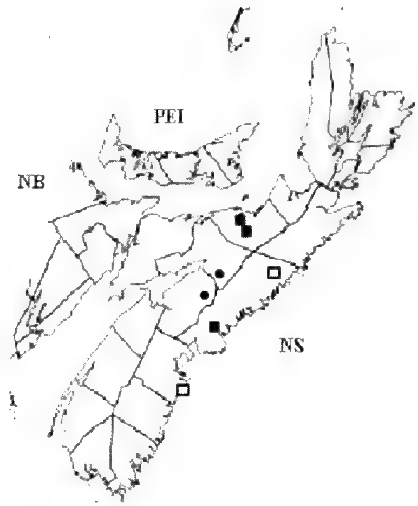


FIGURE 3. Distribution of erythristic Maritime Garter Snakes (*Thamnophis sirtalis pallidulus*), in Nova Scotia: Closed circles represent localities where two erythristic adult females were captured. Closed squares represent localities where part-erythristic individuals were captured. Open squares represent localities where only the dorsal colour patterns of two part-erythristic individuals were documented.

Erratum 124(2): 141

Corrected table for paper by Dawson et al. on Wolverine

TABLE 1. Home range size (HR) based on minimum convex polygons (MCP) derived from all VHF radio telemetry locations for the period 25 February – 8 April 2004 for radio-collared Wolverines (*Gulo gulo*) in northwestern Ontario, Canada.

Animal	Estimated Age (yrs)	Number of Days Located	N	100% MCP	95% MCP	50% MCP
F01	1	30	33	316	235	41
F02[1]	1	0	0	–	–	–
F03	1	24	27	495	453	38
F04	3+	14	29	348	332	3
Mean				386	340	27
(SE)				(55)	(63)	(12)
M01	2	29	39	1898	1434	247
M02	1	13	15	2509	2509[2]	182
M03	3–4	29	40	1685	1308	209
Mean				1791	1371	228
(SE)				(106)	(63)	(19)

[1] F02 was killed prior to the VHF monitoring period.
[2] Due to the low number of locations for this animal analysis results for 95 MCP was the same as for 100 MCP and all results for M02 are not included in the mean HR calculations

Mailing date of the previous issue 124(2): 25 May 2011

Articles

Notes

(continued on inside back cover)

ISSN 0008-3550

The CANADIAN FIELD-NATURALIST

Published by THE OTTAWA FIELD-NATURALISTS' CLUB, Ottawa, Canada

Volume 124, Number 4 October–December 2010

To communicate with the Club, address postal correspondence to: The Ottawa Field-Naturalists' Club, P.O. Box 35069, Westgate P.O. Ottawa, Canada K1Z 1A2, or e-mail: ofnc@ofnc.ca.
For information on Club activities telephone (613) 722-3050 or check www.ofnc.ca

The Canadian Field-Naturalist

The *Canadian Field-Naturalist* is published quarterly by The Ottawa Field-Naturalists' Club. Opinions and ideas expressed in this journal do not necessarily reflect those of The Ottawa Field-Naturalists' Club or any other agency.

All manuscripts intended for publication except Book Reviews should be addressed to the Editor and sent by e-mail (attached) or postal mail (with disk).

Book-review correspondence should be sent by e-mail or postal mail to Roy John, Book-review Editor.

Subscriptions and Membership

Subscription rates for individuals are $33 per calendar year. Libraries and other institutions may subscribe at the rate of $50 per year (volume). The Ottawa Field-Naturalists' Club annual membership fee of $33 (individual) $35 (family) $50 (sustaining) and $500 (life) includes a subscription to *The Canadian Field-Naturalist*. All foreign subscribers and members (including USA) must add an additional $5.00 to cover postage. The club regional journal, *Trail & Landscape*, covers the Ottawa District and Local Club events. It is mailed to Ottawa area members, and available to those outside Ottawa on request. It is available to Libraries at $33 per year. Subscriptions, applications for membership, notices of changes of address, and undeliverable copies should be mailed to: The Ottawa Field-Naturalists Club, P.O. Box 35069, Westgate P.O. Ottawa, Canada K1Z 1A2. Canada Post Publications Mail Agreement number 40012317. Return Postage Guaranteed. Date of this issue: October – December 2010 (July 2011).

COVER: J.-F. Desroches in the habitat of the Boreal Chorus Frog, on the flatlands of the Cabbage Willows Bay, Québec, in June 2002 (Photo by Louis-Philippe Gagnon) *see* A Herpetological survey of the James Bay area. See pages 299–315.

The Canadian Field-Naturalist

Volume 124, Number 4 October–December 2010

A Herpetological Survey of the James Bay Area of Québec and Ontario

JEAN-FRANÇOIS DESROCHES[1], FREDERICK W. SCHUELER[2], ISABELLE PICARD, and LOUIS-PHILIPPE GAGNON

[1]Cégep de Sherbrooke, Département des Techniques de bioécologie, 475 du Cégep, Sherbrooke, Québec, J1E 4K1 Canada
[2]Bishops Mills Natural History Centre, RR#2, Bishops Mills, Ontario, K0G 1T0 Canada

Desroches, Jean-François, Frederick W. Schueler, Isabelle Picard and Louis-Philippe Gagnon. 2010. A herpetological survey of the James Bay area of Québec and Ontario. Canadian Field-Naturalist 124(4): 299–315.

In May-June 2002, as part of a survey of a variety of taxa in the James Bay region of Ontario and Québec, we surveyed the poorly documented herpetofauna of this region. In Ontario we visited sites near Moosonee that FWS had previously surveyed in 1971-1972, and continued ongoing herpetological monitoring around Cochrane. In Québec we surveyed the inland James Bay Road, and roads to four settlements along the coast. American Toad (*Anaxyrus americanus*), Spring Peeper (*Pseudacris crucifer*), and Wood Frog (*Lithobates sylvaticus*) were widespread and abundant throughout. Blue-spotted Salamander (*Ambystoma laterale*) and Garter Snake (*Thamnophis sirtalis*) were widespread and common in Québec and at the study site near Cochrane. We obtained the first taped calls and voucher specimen of the Boreal Chorus Frog (*Pseudacris maculata*) from Québec, and failed to find it at the settlement and airport of Moosonee where it had been present in 1972. A significant range extension was for the Two-lined Salamander (*Eurycea bislineata*), which we found 200 km north of its previously known range in northwestern Québec. Despite extensive searches, the species was not found north of 52°05'N. The Mink Frog (*Lithobates septentrionalis*) was widespread and relatively common in Québec, but was sought but not found in Ontario. The Leopard Frog (*Lithobates pipiens*) was only found at two Québec sites, including one where it was reported in 1974, but it has not been found at any of the Ontario sites where it was found in the 1970's. We present some suggestions for the further study of the herpetofauna of the area, and review evidence for contacts between eastern and western lineages of widespread species.

En mai et juin 2002, dans le cadre d'un inventaire faunique dans la région de la baie James, en Ontario et au Québec, nous avons inventorié la faune herpétologique, laquelle est très peu documentée dans cette région. En Ontario nous avons visité des sites près de Moosonee, que l'un de nous (FWS) avait inventorié en 1971-1972, puis nous sommes allés aux environs de Cochrane. Au Québec l'inventaire s'est majoritairement fait le long de la route de la baie James et des routes d'accès aux villages. Le Crapaud d'Amérique (*Anaxyrus americanus*), la Rainette crucifère (*Pseudacris crucifer*) et la Grenouille des bois (*Lithobates sylvaticus*) sont répandus et communs sur toute l'aire d'étude. La Salamandre à points bleus (*Ambystoma laterale*) et la Couleuvre rayée (*Thamnophis sirtalis*) sont répandues et communes au Québec et près de Cochrane. Nous avons réalisé les premiers enregistrements de chants et collecté le premier spécimen de Rainette faux-grillon boréale (*Pseudacris maculata*) pour le Québec, et n'avons pu la retrouver à Moosonee et à son aéroport, où l'espèce avait été recensée en 1972. La seule extension d'aire significative a été faite pour la Salamandre à deux lignes (*Eurycea bislineata*), trouvée à 200 km au nord de son aire de répartition connue dans le nord-ouest du Québec. Malgré des recherches intensives, elle n'a pas été vue plus au nord que 52°05'N. La Grenouille du Nord (*Lithobates septentrionalis*), est répandue et relativement commune au Québec mais n'a pu être trouvée en Ontario. La Grenouille léopard (*Lithobates pipiens*) a seulement été recensée à deux endroits au Québec, incluant un site où l'espèce avait été trouvée en 1974, mais n'a pu être trouvée en Ontario dans les sites où on la retrouvait dans les années '70. Nous présentons quelques suggestions de futures études sur l'herpétofaune de cette région, et discutons des liens entre les formes de l'ouest et celles de l'est pour les espèces répandues.

Key Words: amphibians, *Ambystoma laterale*, Blue-spotted Salamander, *Eurycea bislineata*, Two-lined Salamander, *Anaxyrus americanus*, American Toad, *Pseudacris crucifer*, Spring Peeper, *Pseudacris maculata*, Boreal Chorus Frog, *Lithobates sylvaticus*, Wood Frog, *Lithobates pipiens*, Leopard Frog, *Lithobates septentrionalis*, Mink Frog, *Thamnophis sirtalis*, *Thamnophis sirtalis sirtalis*, *Thamnophis sirtalis pallidulus*, Garter Snake, distribution, range extension, first record, amphibian decline, morphometry, boreal, James Bay, Québec, Ontario.

In May-June 2002, as part of a survey of a variety of taxa in the James Bay region of Ontario and Québec, we surveyed the herpetofauna of this region in order to exploit roads that have not been previously surveyed by herpetologists, to provide data for future comparisons, and to compare current observations with previous surveys (Schueler 1973; Schueler and Karstad 1975). The logistical difficulties of travel, distance from

academic centres, and especially low species diversity, have left the herpetofauna of the James Bay area poorly documented and infrequently studied. Increased human activity in the area makes it important to determine the current status of species, and global warming makes it especially important to delimit northern range limits, in order to be able to document anticipated northward range expansions. Previous herpetological studies in the James Bay drainage of northwestern Québec and northeastern Ontario include Williams 1920; Gaige 1932; Bleakney 1959; Ashton et al. 1973; Schueler 1975; Schueler and Cook 1980, Bleakney 1954; Cook 1964; McCoy and Durden 1965; MacCulloch and Bider 1975; and Cook 1983.

Our goals in the two provinces were somewhat different. On most of the Québec route we were undertaking initial surveys, similar to those undertaken in 1971-1974 (Schueler 1973; Schueler and Karstad 1975), while in Ontario (and Lac Douay, Québec) we were re-visiting sites we had surveyed before, in some cases many times, and revisiting places where we could document the failure to find species found there in the past, and give GPS geographic co-ordinates for several sites located only verbally in those publications. We also sought other taxa such as small mammals, crayfishes, and terrestrial and freshwater molluscs (Québec results in Picard and Desroches 2003*).

Study Area and Chronology

Figure 1 shows our route and the area studied. The James Bay area contains many wetlands, oligotrophic lakes, bogs and boggy creeks. Large rivers flow into the Bay, those in Ontario mostly dammed for hydroelectric power in the 1930's, while those in Québec were impounded and diverted in the 1970's (Lacasse 1983) or planned (Hydro-Québec 2006*). The average daily annual air temperature ranges from about -2.5°C and the extremes of mean annual temperatures are about – 26°C and 21°C. The extremes of temperature are – 48°C and 36.5°C and the average annual total precipitation is 600-900 mm (Société d'énergie de la Baie James 1978; Environment Canada 2006*).

The south and west shores of James Bay are grassy tidal flats with irregular patches of shrubby willows, which we visited at the mouth of Whitetop Creek in the Moose River estuary northeast of Moosonee, and at Cabbage Willows Bay, on the west shore of Rupert Bay west of Waskaganish. This zone is very dynamic because of the combined effects of wind and ice and isostatic rebound from the weight of Wisconsinian glaciers. Around Rupert Bay the ground rises as much as 3 mm/year (Champagne 1982). Our topographic maps (based on 1955 aerial photos) plotted many of the sites where we heard Boreal Chorus Frogs at Cabbage Willows in the open water of the bay, and there have been major changes in the landscape around our camp there within living memory (Bill Jolly, personal communication). This zone of grassy and shrubby vegetation encroaches on the Bay, and is encroached on by the inland Spruce-dominated Boreal Forest. Tidal amplitude is often augmented or diminished by the strength and direction of the wind. The vegetation in these flats is a sward of grass and widely spaced shrubs (mostly *Salix* and *Alnus*). Near our Whitetop Creek camp, Ontario, there are many small ponds in depressions in the ground and in backwater channels of small creeks, while near our Cabbage Willows Bay camp, Québec, there are almost no ponds in the *Salix/Alnus* zone. On 23-30 May 2002 Larry Frazer (LF) and FWS travelled by train and boat to sites around Moosonee and on the west bank of the mouth of the Moosonee River that had been surveyed in 1971-1972 (Schueler 1973).

From 14-23 May 2002 Aleta Karstad and FWS (and FWS & LF, 30-31 May) continued monitoring around Cochrane that began with a visit in 1972 (see avian results in Schueler et al. 1974). The Ontario Clay Belt around Cochrane is rolling or flat lacustrine clays with *Populus* and *Picea* forest, extensively cleared for grass-based agriculture, with large *Sphagnum/Picea mariana* (Black Spruce) muskegs. Our Long Lake study site south of Cochrane, at the Hwy 11 Long Lake picnic area, 48°55'N, 80°58'W, is where a paved highway was left behind in smoothing a curve. Poplar woods, muskeg, and the shore of a narrow lake are in close juxtaposition to a permanent borrow pit pond and small *Typha* marsh where Wood Frogs have bred abundantly. Ruts in a 2 km clay trackway in the woods along the lake hold water in which amphibians both resort and breed. Areas along this trackway were clearcut in 1999-2000. FWS, Aleta Karstad, and others have made autumnal visits here in 1972 (Schueler et al., 1974), 1977, 1983-1987, 1989, 1990, 1992, 1993, 1995, 1997, 2000, and 2001, and spring visits in 1983 and 1997.

From 1-28 June 2002, all the authors and LF surveyed the James Bay region of northwestern Québec by road, west of 77°W, from 48°30' to nearly 54°N latitude. Most of the area in Québec is located in the Canadian Shield, with Black Spruce and moss forest grading into Black Spruce and lichen forest north of 52°N. The Black Spruce is the most abundant tree, but Balsam Fir (*Abies balsamea*) and Jack Pine (*Pinus banksiana*) are also common, and some deciduous tree species, such as the Paper Birch (*Betula papyrifera*) and the Trembling Aspen (*Populus tremuloides*) are found in sheltered and southern sites.

Methods

We sought amphibians and reptiles at previously known sites, those that looked promising, or that had been identified as promising on topographic maps. Records were obtained by 1) active searching, especially for the eggs of amphibians and the shed skins of snakes, 2) turning cover objects such as rocks, logs, artificial debris, 3) listening for calling at vehicle stops along roads (we recorded the intensity of calling as the Wisconsin Calling Index, Mossman 1990*), and 3)

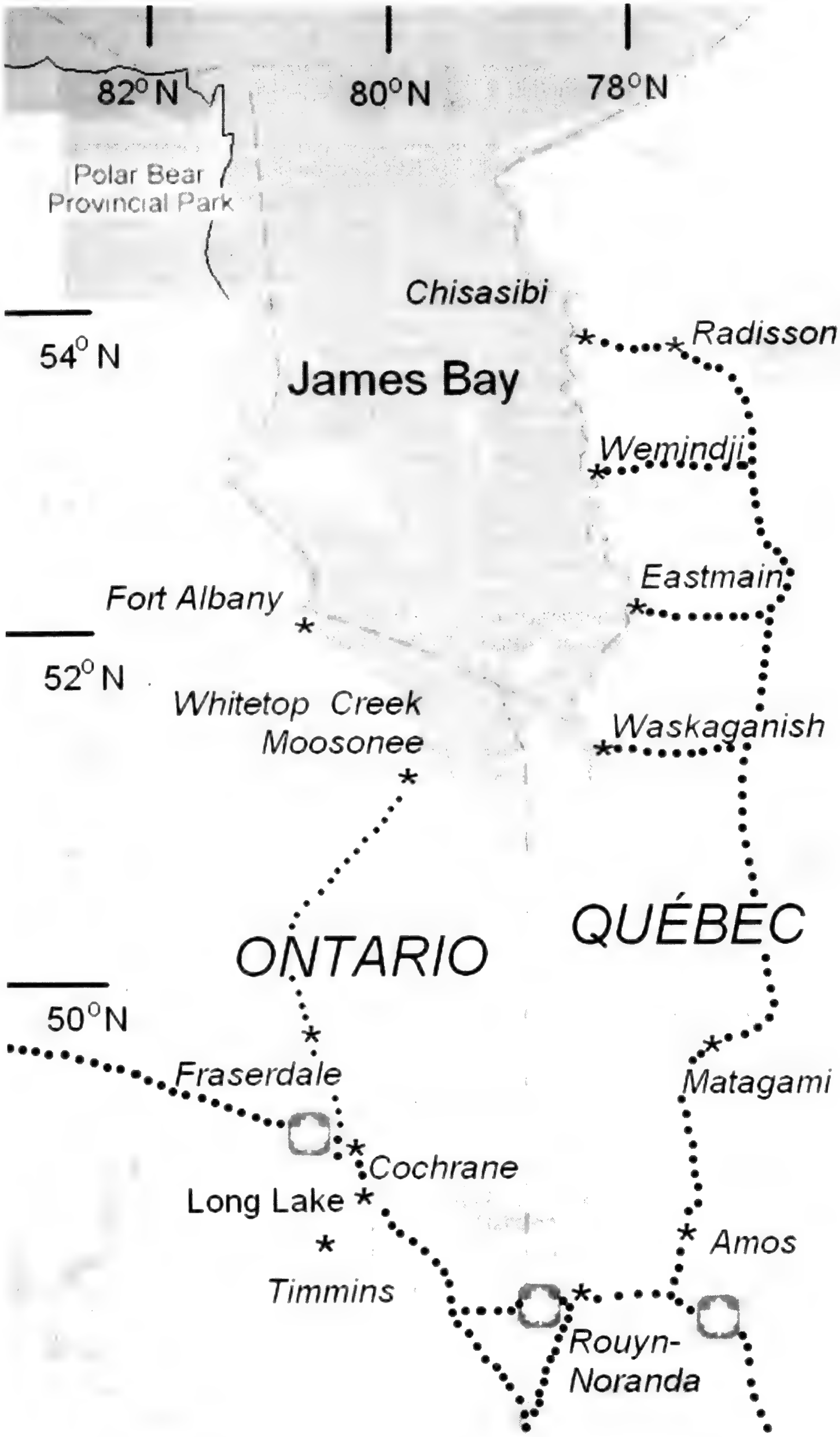


FIGURE 1. Location of the study area, and routes travelled in 2002.

road-hunting at night in areas where we anticipated that breeding amphibians would cross roads. Because we were generally not staying in camps more than overnight, permanent stations with traps and drift fences were not used, and because oviposition habitats are scattered through extensive wetlands, we did not undertake the fine-mesh dipnetting that would have been necessary to capture small larvae of some species. Because we concentrated our attention on small-scale aquatic habitats, we did not adequately survey habitats where terrestrial Redback Salamanders *(Plethodon cinereus)* might have been found. We recorded our location by GPS, and associated each observation with air temperature and other weather conditions. All specimens preserved during the 2002 survey are deposited at the Canadian Museum of Nature (CMNAR 35488-35622), and all the records are deposited in the databases of the Ontario Herpetofaunal Summary (OHS) (and subsequently the Ontario Herp Atlas) and the Québec Atlas of Amphibians and Reptiles (AARQ). All amphibian and snake measurements for Québec were taken by JFD from preserved specimens in July 2003 (except a few snakes released after measurement). Digital calipers were used for amphibian measurements and a metric tape for snakes measurements. Snout-vent length (SVL) was taken from the tip of the snout to the end of the cloacal slit in salamanders, and from the tip of the snout to the cloacal opening in anurans and snakes. In snakes, scale counts were done twice to reduce the possibility of mistake. Tadpole labial tooth row formula follows Altig (1970).

In Ontario we attempted to sample all species at the Long Lake study area. We drove roads and listened at sites near potential hibernation sites and breeding wetlands throughout the area to try to find Leopard Frogs in areas where we had found them in 1971 and 1972, and explored habitats around Cochrane for Mink Frogs. We took the Ontario Northland train to Moosonee, and travelled by boat to camp at several sites on the shores of the Moose River around and northeast of Moosonee, exploring surrounding areas on foot. From 27-29 May we camped at the mouth of South Whitetop Creek (51°22.3'N 80°26.6'W), 600m SW of our 1971-72 camp at the mouth of North Whitetop Creek (51°22.5'N 80°26.2'W, Schueler 1973; Schueler et al. 1974).

In Québec we surveyed the inland James Bay Road, and the roads to the four rivermouth Cree villages: Waskaganish (Rupert River, 51°29'N 78°45'W), Eastmain (Eastmain River, 52°15'N 78°30'W), Wemindji (Maguatua River, 53°00'N 78°48'W), and Chisasibi (La Grande River, 53°47'N 78°54'W). Potentially productive herpetological/malacological habitats were marked on a 1:50 000 topographic map, and we stopped at 5-10 of these preselected stations each day, especially targetting streams for *Eurycea* salamanders and rocky lakes for freshwater limpets. We drove roads and listened at night on the roads around some settlements. The roads reach the tidal mouths of the rivers, but only at Chisasibi is the open coast accessible by road. Cabbage Willows Bay was reached by boat, and we camped from 10-13 June at a traditional local camp on the Novide River (51°30.9'N 79°16.7'W).

We summarize calling for anuran species by latitude and date. For most species this includes only evening and nocturnal calling (20h00 – 03h00) because diurnal calling is of more inconsistent intensity.

For *Lithobates* which seem to have declined in northeastern Ontario, we compiled tables of the number of records of the apparently declining species against the common *Lithobates sylvaticus* in FWS's observation database, and compared them with the number of records by other observers in the OHS database from Cochrane District (OHS records to entry number 264574, March 2005, from Michael Oldham (Ontario Herpetofaunal Summary 2005*)). FWS's data entry is not complete for all years, and the activities pursued and areas visited were not always the same, but in all decades most activity has been monitoring and exploration in the Clay Belt centred on the Long Lake study area. We use our data to form hypotheses of changes in relative abundance which we test as contingency tables of others' observations in the OHS data.

Our species distribution maps plot our records with OHS records and museum and literature records.

Results

Eight species of amphibians and one reptile were found during the survey; Blue-Spotted Salamander (*Ambystoma laterale*), Two-lined Salamander (*Eurycea bislineata*), American Toad (*Anaxyrus americanus*), Spring Peeper (*Pseudacris crucifer*), Boreal Chorus Frog (*Pseudacris maculata*), Wood Frog (*Lithobates sylvaticus*), Leopard Frog (*Lithobates pipiens*), Mink Frog (*Lithobates septentrionalis*) and Garter Snake (*Thamnophis sirtalis*).

Table 1 gives nocturnal air temperatures and average time of sunset at the average latitude of records for the weeks of the survey. Environment Canada (2010*) ranked this spring as "neutral" on the "El Niño Southern Oscillation" pattern of weather variation. Along our route there was little rain (we experienced rain only on 15, 16, 24, 29, and 31 May, 7, 16, 18, 20, and 21 June, usually for short periods). This lack of rainfall was not characteristic of the region in 2002, as it often rained heavily after we had left an area. We encountered falling snow on 16 to 20 and 24 May, and 2 and 5 June.

Ambystoma laterale Blue-Spotted Salamander, Salamandre à points bleus

The Blue-spotted Salamander was found at five different locations in Québec including all four Cree villages (Figure 2). Our northernmost record (53°47.5'N) was made at Chisasibi and is about 24 km north of the previous range limit (MacCulloch and Bider 1975). Specimens (all adults) were mostly found under objects such as woody debris. Eggs and larvae were not

TABLE 1. Weekly nocturnal air temperatures during the 2002 James Bay herpetological survey.

Mean, minimum and maximum air temperatures recorded in our databases from 22h00-24h00 for each week during the 2002 James Bay herpetological survey. Latitudinal range and number of anuran auditory records and time of sunset (EDT, from Garmin GPS software) for the average location of calling records, are also presented.

Cochrane early	(14-16 May, 48°32' – 48°55' N)	10.0°C (0-12.5°C): 22 records, 20h58
Moosonee area	(24-29 May, 51°16' – 51°22' N)	9.4°C (0-14°C): 43 records, 21h23
Cochrane late	(30-31 May, 48°55'– 49°8' N)	14.8°C (14-16°C): 19 records, 21h17
Québec Week 1:	(1-7 June, 48°13' – 51°29' N)	11.8°C (8°-13°C): 59 records, 21h20
Québec Week 2:	(8-14 June, 51°13' – 51°35' N)	4.0°C (-2.5°-12°C): 58 records, 21h32
Québec Week 3:	(15-21 June, 51°21' – 53°48' N)	12.8°C (7°-20°C): 110 records, 21h37
Québec Week 4:	(22-28 June, 46°51' – 53°58' N)	15°C (15°-15°C): 20 records, 21h38

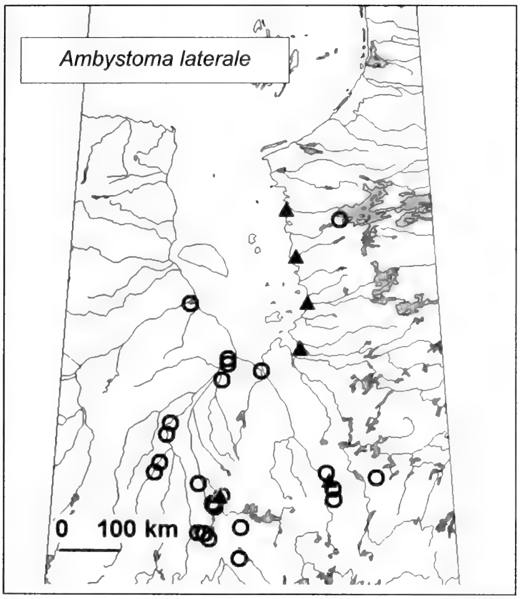


FIGURE 2. Observations of the Blue-spotted Salamander (*Ambystoma laterale*), around James Bay. triangles = our observations in May and June 2002, open circles = previous records.

observed, but the failure to find larvae is doubtless due to the lack of fine-mesh dipnetting. As specimens died during transportation and were preserved in formalin, it was impossible to genetically determine if they were pure *A. laterale* or hybrids. However, measurements (SVL (average 53.8 mm; range 50.0-60.4 mm), head width (7.5 (6.9-8.1) mm) and internarial distance (2.97 mm (2.59-3.40) mm; n = 6) do not suggest that they are anything but pure *A. laterale* (Lowcock et al. 1992). The species is also known from many collections in previous years from the Long Lake study area (CMNAR specimens, OHS records) and is widespread in northeastern Ontario (MacCulloch 2002). Fifteen specimens we have previously submitted for genetic examination from Long Lake study area and elsewhere in the Ontario Clay Belt are pure *A. laterale* (LL; Jim Bogart, University of Guelph, *in litt.* 15 February 2005).

Eurycea bislineata **Two-lined Salamander, Salamandre à deux lignes** :

The Two-lined Salamander was sought in 16 different rivers and brooks (Table 2 and Figure 3) in Québec. Habitat at most of them seemed adequate for the species: clear running water, rocky shores, substrate of sand and gravel, and adjacent forest, but the species was found in only 4 stations. All were under rocks at the margin of rivers except for two larvae that were on the bottom in water. The most northern record was made at Eastmain Rd, 18.1km WNW the James Bay Road, where a rocky brown-water river runs under the road in three large culverts, 52°05'N, representing a range extension of about 200 km to the north (see distribution maps in: Cook 1984; Petranka 1998). North

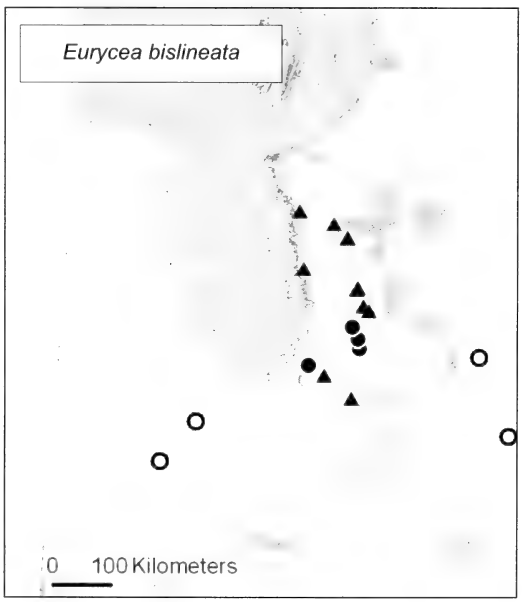


FIGURE 3. Observations of the Two-lined Salamander (*Eurycea bislineata*), around James Bay. filled circles = *Eurycea* present (June 2002), triangles = *Eurycea* not found despite search in suitable habitat (June 2002), open circles = previous records of *Eurycea*.

TABLE 2. Streams searched for the Two-lined Salamander in James Bay, Québec, in June 2002.

Location	Habitat	Date	Presence
Along James Bay road, 50°56.73'N 77°38.82'W	Pebble and soft-mud brook	27 June 2002	No
Waskaganish access road, 51°19.53'N 78°17.47'W	Rocky dark brown water creek in burned Black Spruce forest	14 June 2002	No
Rupert River, 51°29.53'N 78°41.33'W	Large river, clear water, rocky bottom	11 June 2002	Yes (CMNAR 35488)
Pontax I River, 51°44.02'N 77°23.02'W	Clear-water river, gravel bottom, rocky shores	15 June 2002	Yes (CMNAR 35534)
Jolicoeur River, 51°52.98'N 77°25.73'W	Clear brown-water river, gravel and rocky bottom	16 June 2002	Yes (CMNAR 35535)
Eastmain access road, 52°4.92'N 77°33.63'W	Rocky brown-water river, under road in 3 large culverts	18 June 2002	Yes (CMNAR 35551)
Eastmain River, 52°19.30'N 77°06.30'W	Sandy flowing brook below low Beaver (*Castor canadensis*) dam	19 June 2002	No
Opinaca River, 52°23.60'N 77°15.10'W	Clear river, rocky bottom and shores	19 June 2002	No
Pilipas River, 52°39.82'N 77°23.45'W	Clear-water river, 5 m wide, gravel and rocky bottom	19 June 2002	No
Along James Bay road, near km 143, 52°40.83'N 77°22.25'W	Clear-water river, 5 m wide, rocky bottom, shores with alders	27 June 2002	No
Wemindji access road, 53°0.75'N 78°46.27'W	Clear-water river, 4 m wide, gravel bottom	26 June 2002	No
Along James Bay road, 53°27.93'N 77°35.08'W	Clear-water river, 5-10 m wide, gravel bottom	20 June 2002	No
Along James Bay road, at km 566, 53°28.70'N 77°36.10'W	Clear-water stream, 3 m wide, gravel and rocks on bottom	25 June 2002	No
Chisasibi access road, 53°42.58'N 77°55.98'W	Dark brown-water stream, 4 m wide, rocky bottom	24 June 2002	No
Longue-Pointe road, north of Chisasibi, 53°48.0'N 78° 39.8'W	Clayey brown-water brook/creek with rock/cobble bed	23 June 2002	No
Longue-Pointe road, north of Chisasibi, 53°55.37'N 78° 51.23'W	Clear-water river, 30 m wide, rocky bottom and shores	23 June 2002	No

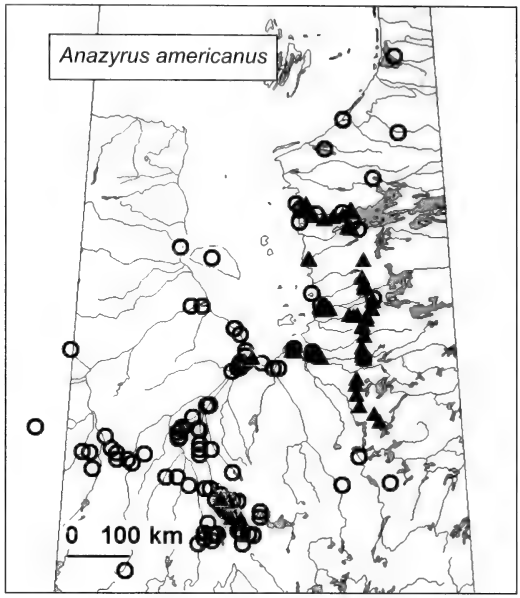


FIGURE 4. Observations of the American Toad (*Anazyrus americanus*), around James Bay. triangles = our observations in May and June 2002, open circles = previous records.

of here, no specimens were found despite many searches. Our observations are the most northern in the James Bay area, but the species has been reported farther north east of our study area: 190 km farther north about 260 km east in northern Québec (Fortin 2006), and to almost 53°30'N in Labrador (Maunder 1997; Fortin 2005).

Streams in the Clay Belt are gravelly only in short stretches at riffles, and this may explain the apparent absence of this salamander in the southernmost part of our study area in Québec (as proposed by (Bider and Matte 1996) and in the Ontario Clay Belt. The only northern Ontario records are along the Abitibi River, halfway between Fraserdale and Moosonee, in the Onakawana River (Kamstra 1983), and Mowbray Creek, a tributary of the Opisatika River (8 Sept. 1990, ROM 20673, collected by G. Mornal, and S. De Forlet).

Anaxyrus americanus American Toad, Crapaud d'Amérique

The American Toad was observed or heard at 95 different locations in Québec (103 records, 69 auditions, 2 on road), and 28 in Ontario (35 records, 21 auditions, 9 on road), throughout the study area except the extreme south of our Québec route, which we visited during a cold spell. (Figure 4). When we first arrived in the Cochrane area, toads were not calling and were active on the roads, but when we were at Moosonee, and for much of the rest of the survey, the breeding season was at its peak, many index 3 choruses were heard, and we saw eggs and tadpoles in some places. Eggs were seen

TABLE 3. Calling index for American Toads, recorded in 2002 in the James Bay area. Number of evening and nocturnal (after 20h00) stations where the species was heard at index1 (few calling)/ index 2 (small chorus)/ index 3 (full chorus) at the indicated dates and latitudes (maximum index recorded for each site on each day).

Latitude/ date	14–15 May	25–30 May	1–7 June	8–14 June	15–21 June	22–28 June
53° to 54°	–	–	–	–	5/1/0	5/0/0
52° to 53°	–	–	–	–	9/8/8	none
51° to 52°	–	2/0/3	1/6/1	3/4/3	0/0/1	none
50° to 51°	–	–	1/0/1	–	–	none
48°30' to 50°	none	01/02/03	none	–	–	none

TABLE 4. Calling index for Spring Peepers, recorded in 2002 in the James Bay area. Number of evening and nocturnal (after20h00) stations where the species was heard at index1 (few calling)/ index2 (small chorus)/ index3 (full chorus) at the indicated dates and latitudes (maximum index recorded for each site on each day).

Latitude/ date	14–15 May	25–30 May	1–7 June	8–14 June	15–21 June	22–28 June
53° to 54°	–	–	–	–	2/7/5	4/1/0
52° to 53°	–	–	0/0/8	–	6/6/14	1/0/1
51° to 52°	–	1/0/11	0/4/2	5/6/5	2/0/0	0/1/0
50° to 51°	–	–	–	–	–	none
48°30' to 50°	0/1/11	0/0/5	–	–	–	1/1/0

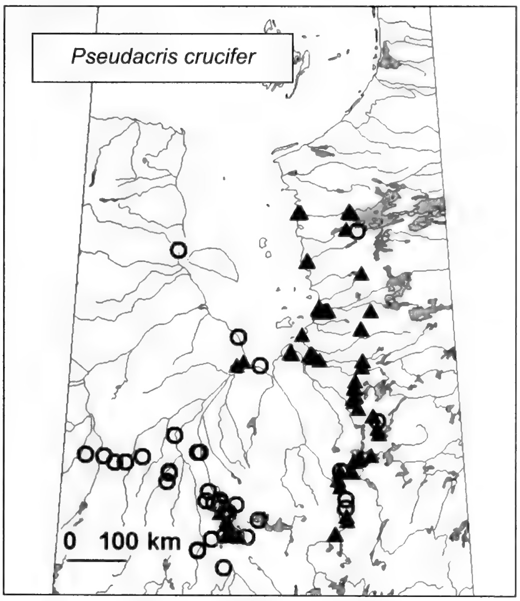


FIGURE 5. Observations of the Spring Peeper (*Pseudacris crucifer*), around James Bay. triangles = our observations in May and June 2002, open circles = previous records.

in Québec side from 7 to 20 June. Table 3 presents the maximum nocturnal call index for the species, by latitude and date. Our results confirm that the American Toad is a common and widespread species in the study area. Its range goes 300 km further north in Québec (Cook 1984; Desroches and Rodrigue 2004) and it is widespread in northern Ontario (MacCulloch 2002).

Pseudacris crucifer **Spring Peeper, Rainette crucifère**

The Spring Peeper was found at 86 different locations in Québec (89 records, 83 calling), and 35 in Ontario (48 records, 45 calling), throughout the study area (Figure 5 and Table 4). This species is widespread in the southern half of the James Bay area of Ontario (MacCulloch 2002) and Québec (Desroches and Rodrigue 2004). Our northernmost record (53°48'N) at Radisson is about 36 km north of the previous range limit in Québec (MacCulloch and Bider 1975). Neither eggs nor tadpoles were observed, but fine dipnetting was not undertaken.

Pseudacris maculata **Boreal Chorus Frog, Rainette faux-grillon boréale**

In James Bay Boreal Chorus Frogs are at the eastern limit of their range, which extends narrowly around the shores of the Bay to the Moose River. Schueler (1973) speculated that this river might have been a barrier that the species had not crossed in dispersing from the west, but the calls of Boreal Chorus Frogs were reported from Cabbage Willows Bay in 1991 (Bider and Matte 1996), strongly suggesting that the range of the species extended into Québec, and inspiring our visit to the site.

In Québec, we found this species only at Cabbage Willows Bay on the west side of Rupert Bay (Figure 6). It was heard from 10-12 June at 14 different locations on the flatlands of the Bay, which represents half of the stations where at least one anuran was heard at Cabbage Willows Bay. Other species heard with the Boreal Chorus Frogs were American Toads (up to index 3), Spring Peepers (up to index 2) and Wood Frogs (few calls). A single specimen was seen and

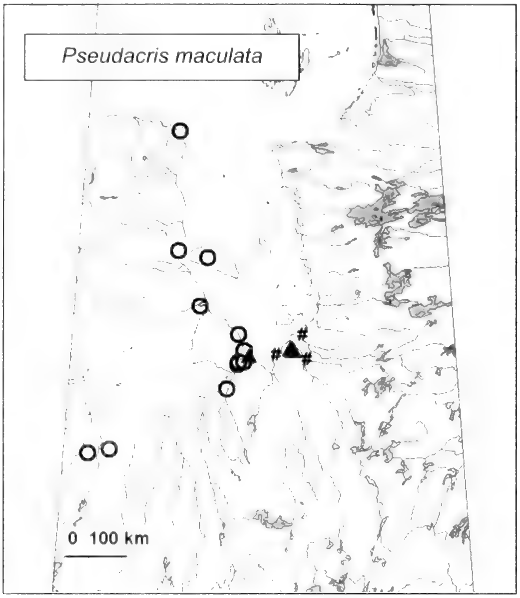


FIGURE 6. Observations of the Boreal Chorus Frog (*Pseudacris maculata*), around James Bay. triangles = our observations (June 2002), # = Fortin et al. 2003 (June 2002) and Ouellet et al. (May-June 2003), open circles = previous records.

caught, on 10 June (51°31.48'N; 79°16.31'W) CMNAR 35522, a green male, SVL 33.39 mm, tibia 14.02 mm [42% of SVL]). Most Boreal Chorus Frog calling was heard during the daylight hours, at a maximum air temperature of 15°C, but some were heard during the night at 0 and 4°C. Water temperature was 16°C in one of the ponds from which calling was heard, on 12 June 12h20, while the air was 14°C. We heard only 1-2 males calling at each station, suggesting either that the population was sparse, or that the breeding season was at its end during our visit to Cabbage Willows Bay (calling had not been intense at Whitetop Creek two weeks earlier). Very small tadpoles with external gills (CMNAR 35622), in the pond where the male Boreal Chorus Frog was caught at Cabbage Willows, may have been of this species or the more abundant Spring Peeper.

In 1971-72 FWS marked the southern range limit of Boreal Chorus Frogs at Store Creek in Moosonee (51°16.26'N 80°30.61'W, Schueler 1973). The OHS contains only one post-1970s record from Moosonee (211741, 31 May 1991 "Moosonee, 3 found, shrubs, mixed forest adj[acent] area, pond along roadside" by Steve LaForest). In 2002 Boreal Chorus Frogs were not heard from the settlement of Moosonee, nor from the grassy-boggy clearing around the airport, where they were heard in 1972 (north to 51°17.9'N 80°35.6'W). At the airport the habitat still seems adequate, but in town many of the ditches along the streets have been filled in since 1972. We both listened generally around

TABLE 5. Calling index for Boreal Chorus Frogs, recorded in 2002 in the James Bay area. Number of stations where the species was heard at index 1 (few calling)/ index 2 (small chorus)/index3 (full chorus).

Location/date	27–29 May	10–13 June
Whitetop Creek, Ontario	09/04/01	–
Cabbage Willows Bay, Québec	–	15/0/0

Moosonee during our 2002 visit, and walked the entire street grid of the settlement on the night of 26-27 May (22h30-01h45, air 8.3-3.0°C). Boreal Chorus Frogs were heard all around Whitetop Creek (southernmost audition 3.2 km SW mouth S Whitetop Creek 51°21.17'N 80°28.68'W), though the low intensity of the calling heard (Table 5) suggests that the peak of the breeding season had passed before we arrived there.

Boreal Chorus Frog habitat is restricted to grassy flat land with shrubby willows (front cover), some of it below the extreme high tide line. Plants found in the breeding pools (*Spartina* sp.) at Cabbage Willows demonstrate that water was more or less brackish. At Whitetop Creek most calling was from ponds among the *Salix* savanna well above the usual high-tide level (Figure 8), but there were almost no ponds in this zone at Cabbage Willows.

The Boreal Chorus Frog was reported from Cabbage Willows Bay in 1991 (Bider and Matte 1996) but no photos, sound recordings, or voucher specimens were taken, so our records and the sightings and auditions by others at Cabbage Willows Bay and at three sites

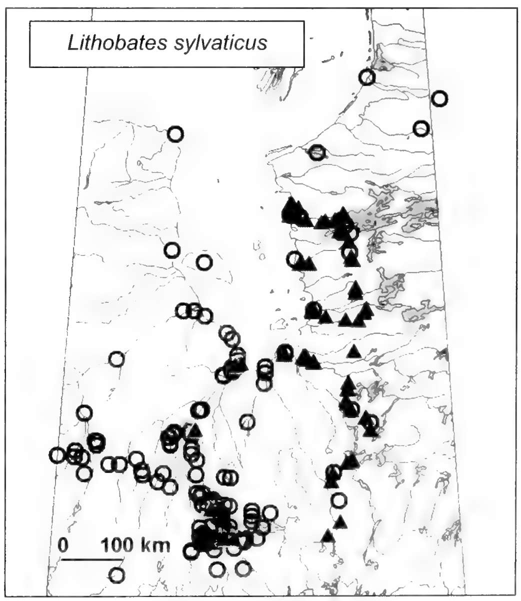


FIGURE 7. Observations of the Wood Frog (*Lithobates sylvaticus*), around James Bay. triangles = our observations in May and June 2002, open circles = previous records.

FIGURE 8. Habitat of the Boreal Chorus Frog, in the *Salix/Alnus* savannah along a tributary of Whitetop Creek, Ontario (Photo by Larry Frazer).

just west, southeast and northeast of Cabbage Willows Bay, on the east coast of James Bay (Fortin et al. 2003; Ouellet et al. 2009) are the first authentic records from Québec. The restriction of the species to barely-supratidal habitats suggests that changes to the salinity of Rupert Bay by projected hydroelectric projects may imperil the species here (Picard and Desroches 2003*).

Lithobates sylvaticus **Wood Frog, Grenouille des bois**

This species is the most frequently seen amphibian in the James Bay area. In Québec we found it at 84 different sites (87 records of which 19 were calling and 18 were eggs) and in Ontario 62 records from 45 sites, of which 47 were calling records, and 10 were eggs (Figure 8 and Table 6). Most auditory records from 14-16 May around Cochrane, and at Moosonee, were index 3 choruses, but these were not actively breeding, as the frogs could not be approached, and no concentrations of egg masses were laid at those chorus sites that could be visited. Scattered egg masses were laid in the ruts along the track at Long Lake. Most of the Québec records are sightings and captures of individuals rather than auditions, reflecting the later season when we visited this area. We heard no index 3 choruses in Québec. Eggs were found at 18 sites in Québec, ranging from 1-20 masses per site, and most of the tadpoles collected were this species. Hatching was observed on 4, 5, and 6 June. Extreme temperature fluctuations in May, may have disrupted normal movement to mass oviposition sites: no eggs were laid in ponds at Long Lake where breeding usually occurs, while 18 egg-

TABLE 6. Calling index for Wood Frogs, recorded in 2002 in the James Bay area. Number of evening and nocturnal (after 20h00) stations where the species was heard at index1 (few calling)/ index2 (small chorus)/ index3 (full chorus) at the indicated dates and latitudes (maximum index recorded for each site on each day).

Latitude/ date	14–15 May	25–30 May	1–7 June	8–14 June	15–21 June	22–28 June
53° to 54°	–	–	–	–	2/0/0	none
52° to 53°	–	–	–	–	3/1/0	none
51° to 52°	–	0/5/12	5/0/0	6/0/0	none	none
50° to 51°	–	–	1/0/0	–	–	none
48°30' to 50°	0/2/7	3/0/0	3/0/0	–	–	none

masses were found at 8 sites in ruts along the track west of the lake, which averaged 6738 L in rectangular volume (length × width × depth; range: 900 – 10000 L, st.dev. = 3440 L; data in Schueler et al. 2010*). The only large clusters of egg masses noted were an estimated 30-40 masses seen from the stopped train in a shallow dark-water Grass/Carex ditch at Coral Rapids, Ontario (50°13.1'N 81°41.0'W – perhaps at the very same site where eggs were seen in 1972, Schueler 1973: 413).

The average SVL for males was 41.73 mm (36.79-47.39, n = 30) and 45.09 mm (40.46-52.17, n = 16). The ratio between the tibia length and the SVL was 0.50 for both sexes, ranging from 0.45 to 0.57 in males (n = 30) and from 0.46 to 0.56 (n = 16 for females).

The mid-dorsal pale line, or stripe, is known to be relatively frequent in northern populations of Wood Frogs from Ontario and Québec, with respective frequencies of up to 76% and 45% reported (Schueler and Cook 1980). In 2002, 58% of the Wood Frogs observed in Québec were striped. In the most recent sizeable sample from Long Lake, 14% of breeding adults from 1997 were striped (22 of 154), the same frequency reported from there in samples from August of 1971 (the site described as "along highways in the vicinity of Cochrane," Schueler and Cook 1980). No Wood Frogs were actually seen around Moosonee in 2002; historically about 55% of the frogs from there are striped (1938-1939 and 1971-1972, Schueler and Cook 1980: 1646). For comparison, about 2% in eastern Ontario and 2.5% in southwestern Québec are striped (FWS and JFD, unpublished data).

Tadpoles of James Bay area Wood Frogs differ from those of the same species in southern locations, in having a tooth-row formula of $\frac{2}{3}$ (2 upper rows [anterior] and 3 lower [posterior]) instead of $\frac{3}{4}$. This was noticed in Wood Frog tadpoles from Hudson Bay by Altig (1970). All our James Bay Wood Frogs tadpoles (from Québec) have a tooth-row formula of $\frac{2}{3}$.

The Wood Frog is a common and widespread species in the James Bay area. It ranges north of the area studied in 2002, as far as 350 km along the coast and 500 km inland in Québec (Cook 1984; Desroches and Rodrigue 2004) and is widespread all over northern Ontario (MacCulloch 2002).

Lithobates pipiens **Leopard Frog, Grenouille léopard**

The Leopard Frog was found at only two stations: Douay Lake and Opinaca River, Québec (Figure 9). The latter is about 120 km south of the northernmost record of the species in the area (MacCulloch and Bider 1975). Two or three males were heard calling at Douay Lake (49°34.8'N 78°4.6'W) at 17h50 on 3 June 2002, at an air temperature of 13°C. The Leopard Frog was reported from this lake in 1974 (Schueler and Karstad 1975). At Opinaca River (52°23.6'N 77°15.1'W), only a single juvenile was found on the shore of a bedrock river with fast current, a habitat that does not correspond to the breeding needs of the

TABLE 7. *Lithobates pipiens* taken in eastern Cochrane District, June and July 1971, May and August 1972.

Location	Habitat		Presence
Moose Twp: mouth N Whitetop Creek, 18.4 km NE Moosonee.	51°22.48'N	80°26.18'W	CMNAR 23818, 24222 **
Moosonee (in town, 1 km radius),	51°16'N	80°39'W	CMNAR 15217 15267 23893 23900 24221 24223 **
1 mile N of Fraserdale,	49°51.82'N	81°36.74'W	CMNAR 15299 #
Clute Twp: 4 miles N of Cochrane (as Lillabelle Lake dam),	49°7.54'N	81°2.27'W.	CMNAR 24246 # **
Cochrane: Commando Lake,	49°3.81'N	81°1.27'W.	CMNAR 14801 # **
Cochrane: CN railway, 1 mile W of Cochrane,	49°3.95'N	81°3.11'W	CMNAR 24252. # **
Hwy 11, 4 miles S of Cochrane,	49°0.09'N	81°1.85'W	CMNAR 24246 # **
Hwy 11, 4-11 mi S Cochrane (as Wicklow River/Hwy 11),	48°56.93'N	81°0.57'W.	CMNAR 15292, CMNAR 24253 # **
Hanna Twp: Long Lake, 12 km NW Tunis (=11 miles SE of Cochrane),	48°54.96'N	80°58.35'W.	CMNAR 24245 # **
0.5 miles W of Frederickhouse, 7 miles W of Cochrane.	49°3.41'N	81°9.56'W	CMNAR 15309, 24396 # ** @
Hwy 101/Moose Creek, 15 miles E of Timmins	48°33.18'N	81°0.47'W	CMNAR 24197 #

site searched for Leopard Frogs 1995-2001
** site searched for Leopard Frogs 2002
@ the location of this site is ambiguous – the frogs from here were actually taken by other members of the party (Schueler et al. 1974) and FWS didn't visit the site in 1972. "0.5 miles W of Frederickhouse" is 49°5.20'N 81°10.16' W – but this provides no habitat for *L. septentrionalis,* which was also taken there, and it is 6.5 miles WNW of Cochrane. The co-ordinates given in the table are 3.3 km S of Frederickhouse, just east of Clute Lake, and could be considered half a mile west of the cluster of houses just west of the Hwy 11 Frederickhouse River bridge, but only 6 miles W of Cochrane directly along Hwy 11.

TABLE 8. Relative frequency of records of Leopard and Wood Frogs in Cochrane District by F.W. Schueler and by other observers in the Ontario Herpetofaunal Summary. The number of *L. pipiens* records are given as as a percentage of the number of *L. sylvaticus* records.

Source and years	*Lithobates pipiens* / *Lithobates sylvaticus*
FWS 1971-1977	28 / 64 – pre-decline – 44% of *Lithobates sylvaticus* records
OHS pre 1980	*41 / 89 – 46% of Lithobates sylvaticus* records
FWS 1983-1990	0 / 107 – observers unaware of decline – 0%
OHS 1981-1991	*4 / 89 – 4% of Lithobates sylvaticus* records
FWS 1992-2002	4 / 183 – aware of decline in *L. pipiens* – 2% *of L. sylvaticus* records
OHS 1992-2002	0 / 2 (data entry or submission evidently incomplete)

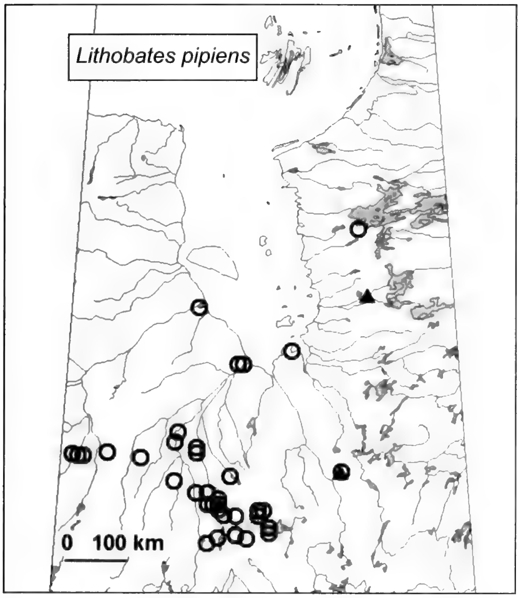


FIGURE 9. Observations of the Leopard Frog (*Lithobates pipiens*), around James Bay. triangles = our observations in May and June 2002, open circles = previous records.

species. It may have come from upstream or adjacent marshy or boggy habitat.

The Leopard Frog seems uncommon on the Québec side of James Bay, though we may have visited many areas during the post-breeding period when the species isn't highly apparent. This species is associated with grassy habitats (Wright and Wright 1949; Dole 1971; Schueler 1982), though Schueler (1973) noted a greater use of aquatic habitats in the James Bay area. Adequate habitats may be scarce on the Québec side of James Bay. Douay Lake, where we heard Leopard Frogs, is bordered with grassy open habitat instead of the usual *Sphagnum* and Ericaceae shore. Several places between Lac Douay and Matagami appeared suitable for *Lithobates pipiens,* including flat mesotrophic sedgey wetlands on the outskirts of Matagami, but we were not able to visit these. The only other records of the species in James Bay region in Québec, are from Point Comfort (Logier and Toner 1961, now Cabbage Willows Bay) and from Nathalie Lake, some 120 km north of Opinaca River (MacCulloch and Bider 1975). Adult people in several of the coastal settlements we visited, and from Fort Albany, Ontario, told us that "big green frogs" were seen when they were children, while youths and children seemed not to know about such frogs; a careful assembly of oral tradition should accompany any investigation of the species status in the region.

Leopard Frogs were not heard or seen at breeding sites or on roads near potential hibernation sites near where were captured in 1971 and 1972 around Cochrane and Moosonee (Table 7), nor near sites where juveniles were found on 16 Sept 1992, south of Val Gagne on Taylor Twp Rd 4 (48°35.2'N 80°38.2'W, CMNAR 35679-35682). Since 1995 FWS has visited every place where he found Leopard Frogs in 1971-1972, in reasonable conditions for finding this species, without success. Leopard Frogs were heard calling on 14 May 2002 at one of the northernmost known Ontario populations, Casey Marsh, 12.3 km NE New Liskeard, Timiskaming District, 47°35'N 79°33'W in the upper Ottawa River drainage.

The widespread failure to find this species in northern Ontario has suggested the hypothesis that there has been a general decline throughout the Arctic drainages of Ontario (Anonymous [Schueler] 1993*; Weller and Green 1997; Seburn and Seburn 1997*; 2000). Declines have been suspected as far south as Algonquin Park in Ontario (Brooks et al. 2003).

Our data suggest a decline around 1977, and a 2×2 G test for OHS records from before and after 1978 is highly significant (Table 8, $G = 29.94249$ $p << 0.001$). The close agreement between the relative frequencies in FWS's and "others" records of the species suggests that there has been a real decline in the apparency of Leopard Frogs to herpetological observers, and that our observations are typical of those of all observers.

While the Leopard Frog is still common in southern Québec and Ontario, it suffered widespread declines in western Canada around 1976-1980 (Koonz 1992; Seburn and Seburn 2000). These declines happened in the populations from the Prairies, from Alberta to Manitoba, which are biogeographically linked to western James Bay populations by the possession of the

TABLE 9. Relative frequency of records of Mink and Wood Frogs in Cochrane District by F.W. Schueler and by other observers in the Ontario Herpetofaunal Summary. The number of *Lithobates septentrionalis* records is given as a percentage of the number of *L. sylvaticus* records.

Source and years	*Lithobates septentrionalis* / *Lithobates sylvaticus*
FWS 1971-1987	40 / 167 – 24% of *Lithobates sylvaticus* records
OHS pre-1990	*33 / 129* – 26% of *Lithobates sylvaticus* records
FWS 1990-2002	6 / 187 – 3% of *Lithobates sylvaticus* records
OHS 1990 & after	*1 / 52* – 2% of *Lithobates sylvaticus* records

TABLE 10. Calling index for Mink Frogs, recorded in 2002 in the James Bay area of Québec. Number of evening and nocturnal (after 20h00) stations where the species was heard at index 1/ index 2/ index 3 at the indicated dates and latitudes (maximum index recorded for each site on each day).

Latitude/ date	1–7 June	8–14 June	15–21 June	22–28 June
53° to 54°	–	–	–	diurnal
52° to 53°	–	–	1/2/2	none
51° to 52°	none	none	diurnal	none
50° to 51°	none	–	–	none
48°30' to 50°	none	–	–	diurnal

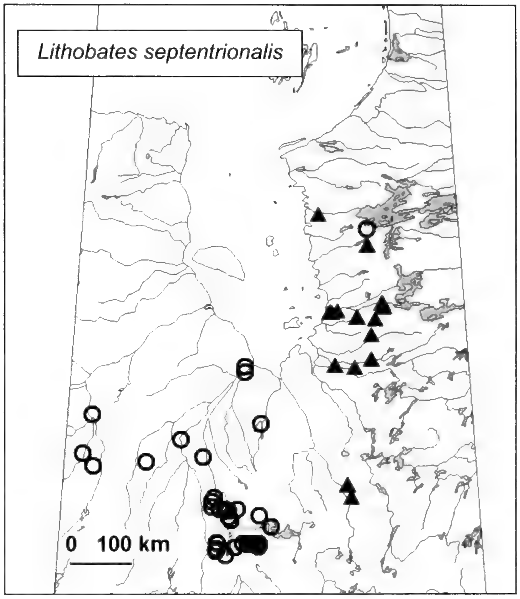


FIGURE 10. Observations of the Mink Frog (*Lithobates septentrionalis*), around James Bay. triangles = our observations in May and June 2002, open circles = previous records.

western mtDNA haplotype in some frogs from Attawapiskat, though those from Moosonee had the eastern haplotype (CMNAR 1971-1972 specimens, Hoffman and Blouin 2004).

Lithobates septentrionalis **Mink Frog, Grenouille du Nord**

This frog was found at 17 different locations in Québec (20 records, 9 calling), all through the study area (Figure 10 and Table 10). Relatively few adults were seen or captured, perhaps due to the fact that this frog is highly aquatic and relatively wary. The species prefers boggy habitat (MacCulloch and Bider 1975), which are well represented on the study area, but which were not extensively entered in our survey. Overwintered tadpoles were observed at six locations; the largest number seen was about 150.

It seems that the Mink Frog is fairly common and widespread in the Québec part of the study area. The known range of this frog goes 450 km farther north than this study examined inland in Québec but not along the coasts of James Bay (see maps in Cook 1984; Desroches and Rodrigue 2004).

In Ontario, Mink Frogs, like Leopard Frogs, seem less widespread than in the 1970's. In 2002 we did not hear or encounter any in our searches and listening around Cochrane, in Moosonee, or at Whitetop Creek, where we had found them in the 1970's. FWS found Mink Frogs in a brief visit to Commando Lake in Cohrane in 1971 (CMNAR 14799), but in 2002 he searched lakes in, and south of, Cohrane's Dury Park to check Rey Brisson's suggestion (personal communication) that the lakes there are "just like" what Commando Lake was like when he was a boy, and when 'greenish frogs' were abundant there. Commando Lake now has mowed shores and domestic Mute Swams (*Cygnus olor*); searches since 1997 had not found any *Lithobates* there until one of three Mink Frogs seen was captured in May 2010 (Schueler et al. 2010*).

Our data (Table 9) suggest a decline around 1990, and counts of OHS records again closely parallel ours in frequency, with Mink Frogs much less frequent after 1990 ($G = 14.02$ $p << 0.005$; but note that 50 of the '1990 and after' OHS *L. sylvaticus* records come from 1990-1991; compare the last line of Table 8).

Bleakney (1958) was the first to report that Mink Frogs in northern Québec breed in June at the same time as the American Toad, the Spring Peeper, and the Wood Frog. He found it unusual that a frog would breed simultaneously in northern and in southern locations. The air temperature for our observations, north of 51°N when Mink Frogs were heard calling, varies

from 24.5°C to 27.5°C by day and from 13°C to 14°C by night (after 20h00). On the week of 15-21 June 2002, between 22h00 and 23h30, choruses of Mink Frogs were heard at index 3 at the same time that Toads and Peepers were calling at index 3 and Wood Frogs at index 2. A female taken on 16 June had enlarged oviducts but had not ovulated, one taken on 27 June extruded eggs as she was handled. It is not known why the breeding season of the Mink Frog is about the same in southern and northern Québec (between 45°N and 54°N), but the longer duration of days in summer in the north may result in a faster accumulation of degree-days of warmth.

The average SVL of males was 54.18 mm (45.96-61.95, n = 5) and for females it was 67.26 mm (58.38-71.32, n = 7). For females this relatively large size is consistent with other samples from Ontario and Québec, but the size of males is lower than that reported for northern males (60-64 mm snout-urostyle length; Schueler 1975). If the step cline in size described by Schueler (1975) is due to the addition of another year of growth to the life cycle (as Pace [1974] suggested for *Lithobates spenocephalus*), then mature frogs from the northern part of our area might be expected to be smaller than those from the south.

Thamnophis sirtalis **Garter Snake, Couleuvre rayée**

The Garter Snake is the only reptile found during the survey. It was found on 15 locations throughout the study area in Québec (Figure 11). Several shed skins were found and these were identified by the dorsal scale row count (always 19) and keeled scales. Many of these observations were made near metal culverts embedded in rock fill under the paved James Bay Road. Our northernmost record (53°47.7'N) at Longue-Pointe, near Chisasibi, is about 24 km north of the previous range limit (MacCulloch and Bider 1975). The species is also known from previous years from the Long Lake study area (CMNAR specimens, OHS records), and one was seen in a clearcut there on 31 May 2002.

All the 14 Garter Snakes captured and examined in Québec during the survey had a yellowish dorsal line and orange to red lateral lines. Bleakney (1959) stated that Garter Snakes from northern Ontario (Abitibi and James Bay areas) often had orange or red stripes, but without distinguishing lateral and dorsal stripes. Snakes from Long Lake are sometimes entirely yellowish with no lateral red, but sometimes are "washed with orange-ochre," "creamy colour, red only between anterior scales," "brightly white-checkered, with lateral red," "dingy olive – orangy-red between scales on anterior ⅓ of body," or "vividly red" over the head and entire anterior third of the body (FWS field notes).

Maps in the literature (see: Bleakney 1959; Cook 1984; Conant and Collins 1998) suggest that the boundary between *T. s. sirtalis* and *T. s. pallidulus* runs at or a little east of the Ontario-Québec border, associated with a west-east cline in ventral scale counts (Bleakney 1959). Our qualitative assignment to subspecies, based

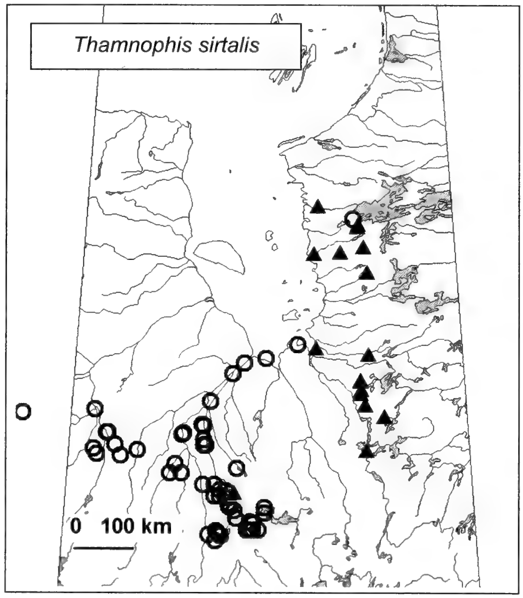


FIGURE 11. Observations of the Garter Snake (*Thamnophis sirtalis*), around James Bay. triangles = our observations in May and June 2002, open circles = previous records.

on colour pattern (striped *vs* checkered in appearance, see Cook 1984), for 11 Québec James Bay snakes, was 8 *pallidulus* and 3 *sirtalis*. Ventral and subcaudal scale counts, the quantitative characters which differ between the subspecies (Bleakney 1959), also suggests our snakes were intermediate between *T. s. sirtalis* and *T. s. pallidulus* (Figure 12). Our ventral scale counts were 151.0 ± 3.2 for males (n = 7) and 145.8 ± 3.8 (n = 5) for females; subcaudal scale counts were 73.1 ± 4.3 for males (n = 7) and 65.3 ± 5.0 for females (n = 4).

The only previous report of the litter size of Garter Snakes from the James Bay area was 6 embryos in a *circa* 70 cm SVL female taken on 17 July 1973 (MacCulloch and Bider 1975). This snake also contained one small egg which likely would have been aborted (F. R. Cook, personal communication). Average counts of embryos for northern locations in western Canada are 12.5 and 18.5 (Larsen et al. 1993), and 10-30 in southern Québec and Ontario (J-FD and FWS, unpublished data; Gregory and Larson 1993). Over the species' range, litter sizes average 27 (Ernst and Ernst 2003). Eight southern Quebec Garter Snakes dissected by JFD contained 12 to 25 embryos (mean = 16.8). Our three pregnant females from James Bay, Québec (taken 4-15 June) contained 35 (65cm SVL), 28 (55.6cm SVL) and 18 (60.4cm SVL) embryos. Litters born to females taken in September of previous years at the Long Lake study area averaged 31

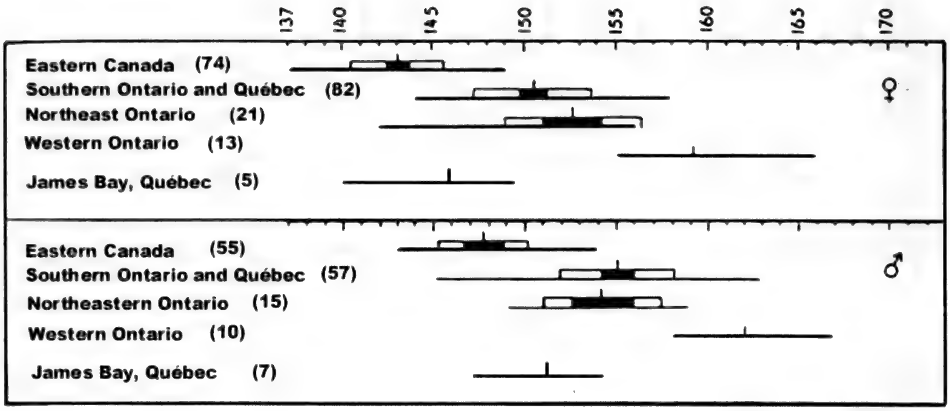


FIGURE 12. Comparison between the number of **ventral** scales for Garter Snakes in Eastern Canada (*T. s. pallidulus*), South Ontario-Québec, and northeast Ontario (*T. s. sirtalis*) [Modified after Bleakney 1959] and our James Bay specimens from Québec and Long Lake (Horizontal line: range; white boxes: standard deviation; black boxes: twice the standard error of the mean; small vertical line: mean)

young (25 [born in captivity the next June], 37 [born 14-15 Sept.], 32 [born 16-17 Sept]). There is no evidence here for a small northern litter size.

The Garter Snake seems to be widespread in the study area, both in rocky and sandy areas in Québec, and in Clay Belt areas like Long Lake and north along the Ontario Northland tracks to James Bay in Ontario. According to local people, there are populations of snakes on some islands in Rupert Bay. The species was also found on Jacob Island just north of Rupert Bay (Ouellet et al. 2009). The huge volumes of broken rock fill at the culverts where we found 70% (16/23) of our snakes (or shed skins) in Québec may provide hibernacula, but all we can say about hibernation in the Clay Belt is that snakes are found at Long Lake in both May and September.

Discussion

The herpetofauna of the area we surveyed, along about 1 200 km of roads, is remarkably uniform. We found only one significant northern range limit (Two-lined Salamander), and the Boreal Chorus Frog is the only species regionally restricted to a habitat that is not widespread in the area. Four species have their known northern range limit near the northern limit of the study area (Blue-spotted Salamander, Spring Peeper, Leopard Frog and Garter Snake).

The apparent declines of *Lithobates pipiens* and *Lithobates septentrionalis* in Ontario are troubling. These species need dedicated monitoring by local naturalists or a concerted season-long survey of all the sites where they have been found in the past (e.g., Table 7), and other sites with favourable habitat features (e.g., Schueler, 2000*).

James Bay thrusts subarctic conditions far south into central North America, so that the transition between subarctic and warm temperate conditions is perhaps as steep in the 1400 km between Moosonee and Baltimore as it is anywhere. This partial barrier, and the contrasted conditions east and west of the Bay, means that phylogenetic contacts between eastern and western stocks are expected here, imposed on the general pattern of postglacial northward dispersal from southern refugia (Cook 1983). Several species have been studied in sufficient detail to make this possible:

Ambystoma laterale seems homogeneous through the region (J. P. Bogart, *in litt.*), but hybrids with *Ambystoma jeffersonianum* (LLJ and LJ genotypes) were collected in Abitibi in 2005, just south of the area studied here (J.-F. Desroches and J. P. Bogart, personal observation). Genetic evaluation of some James Bay specimens would be needed to evaluate the status of the species in this area.

Eurycea bislineata is of Appalachian origin, and may be restricted to rocky watersheds in James Bay and absent from most of the Clay Belt.

Cook (1983) found the easternmost morphological signs of intergradation with the prairie Toad *Anaxyrus americanus hemiophrys* in samples from Whitetop Creek and Moosonee, suggesting early dispersal though grassland habitats of the dewatered Lake Agassiz basin and other post-glacial grasslands.

Austin et al. (2002) concluded that the entire Boreal Forest west to Manitoba was populated by *Pseudacris crucifer* from refugia east of the Appalachians, and that western lineages of this species had not spread very far north, perhaps because they had been held south by grassland habitats of the Prairie Peninsula and on the dewatered Lake Agassiz which provided eastward corridors for grassland species.

Pseudacris maculata, on the other hand, reached Quebec as a western incursive along the shores of Hudson and James bays, though it is also found in the interior of western Ontario (perhaps having spread through grasslands on the dewatered bed of Lake Agassiz). Moriarty and Cannatella (2004) and Moriarty

Lemmon et al. (2007) showed that Saint Lawrence and south-central Ontario populations with *P. triseriata* morphology are genetically *P. maculata*, and must have re-evolved the *triseriata* morphology from Boreal ancestors that spread through the northern grasslands now represented by the shores of James Bay (Moriarty, personnal communication).

The boundary between eastern and western populations of *Lithobates sylvaticus*, which is marked by hints of non-interbreeding and indirect evidence of morphological difference, has not been mapped north of the vicinity of Quebec City (Lee-Yaw et al. 2008). Andrée-Michelle D'Aoust-Messier is surveying this species around James Bay to map the distribution of genotypes and to see how they are associated with the tadpole tooth formula or with morphological traits of adults (see D'Aoust-Messier and Lesbarrères 2010*).

In a mtDNA study of geographic variation in *Lithobates pipiens* throughout its range, only a 1971 sample from Attawapiskat contained both eastern and western haplotype specimens (Hoffman & Blouin 2004). This western influence on the west side of James Bay was perhaps foretold by Schueler's (1973) noting colour differences between frogs from Attawapiskat and Moosonee, but Schueler (1982) found only intermediate values of the east-west variable SPOTTING, and high values of the aquatic-habitat variable GLANDS around the Bay, without enough samples west and south of the Bay to detect a stepped cline that might have reflected the ranges of the two haplotypes in Ontario.

Our study area is supposed to span the junction between *Thamnophis s. sirtalis/pallidulus*, at the south end of the Bay (Bleakney 1959; Cook 1984; Conant and Collins 1998). In New York and New England, this subspecies difference corresponds to the "eastern" and "maritime" lineages of Rye (2000). In western Ontario Rye found that the change in colour pattern (*Thamnophis s. sirtalis/parietalis*) occurred far west of the contact zone between the "eastern" and "western" genetic lineages, and that there was an eastward cline of decreasing ventral count that was not stepped or interrupted at the contact between the lineages (Rye 2000, figure 3.13).

Acknowledgments

Many people and institutions made the James Bay Expedition possible. Ginette Crochetière, Jasmine Larouche, and Johanne Deziel provided accommodation during our visits in James Bay villages. Rey and Carole Brisson, patrons of boreal herpetology, provided their customary lavish support in Cochrane, through an otherwise very stressful time for their family. Aleta Karstad and Larry Frazer accompanied us on some trips, and provided logistic support from home. The Cree Band Councils helped with authorization and in organisation. Bill Jolly ferried us to Cabbage Willows Bay, and Wayne Tomatuk took us around the Moose River. Initial maps of species records were made by Matt Keevil and Daniel Ouellett. The former Eastern Ontario Biodiversity Museum, Mountain Equipment Coop, and Aux Quatre Points Cardinaux provided material assistance. Michèle Steigerwald's help in cataloguing and integrating specimens into the Canadian Museum of Nature collection was invaluable, and Francis Cook has encouraged us in all our northward ventures. This survey was made possible with the financial support of Frank Ross and Donna Richoux and of the Société de la faune et des parcs du Québec, with its program "Faune-Nature." A review of the manuscript by Ross MacCulloch was helpful. We thank everyone for this assistance, and hope that our discoveries repay their efforts.

Documents Cited (marked * in the text)

Anonymous [F. W. Schueler]. 1993. Northeastern Ontario Leopard Frogs. Ontario Herpetological Summary Newsletter, April 1993: 3.

D'Aoust-Messier, A.-M., and **D. Lesbarrères.** 2010. Conservation of northern biodiversity: population genetics patterns observed in populations of Wood Frogs (*Lithobates sylvaticus*) in the James Bay area. CARCNET meetings, Wolfville, Nova Scotia. http://www.carcnet.ca/past_meetings/2010/abstracts2010.pdf

Environment Canada. 2006. Canadian Climate Normals or Averages 1961-1990. http://www.climate.weatheroffice.ec.gc.ca/climate_normals/index_1961_1990_e.html

Environment Canada. 2010. Comparing El Niños – El Niño and La Niña Years 1950-2010 – http://www.ec.gc.ca/adsc-cmda/default.asp?lang=En&n=E0ABE4B3-1 (accessed 24 Oct 2010).

Hydro-Québec. 2006. Eastmain-1-A Powerhouse and Rupert Diversion. http://www.hydroquebec.com/eastmain1a/en/index.html.

Lee-Yaw, J. A., J. T. Irwin, and **D. M. Green.** 2008. Post-glacial range expansion from northern refugia by the wood frog, *Rana sylvatica*, Molecular Ecology 17: 867–884.

Mossman, M. J. 1990. 3 April 1990. Wisconsin Frog and Toad Survey Newsletter.

Ontario Herpetofaunal Summary. 2005. OHS database. Records from Cochrane District extracted on 12 March 2005. Database managed by Natural Heritage Information Centre, Ontario Ministry of Natural Resources, Peterborough, Ontario. (see http://www.mnr.gov.on.ca/MNR/nhic/herps/ohs.html).

Picard, I. and **J.-F. Desroches.** 2003. Inventaire faunique de la région de la baie James, 2002. En collaboration avec la Société pour la nature et les parcs du Canada (SNAP). Rapport réalisé pour la Société de la faune et des parcs du Québec, Québec, 28 pages + 2 appendices.

Schueler, F. W. 2000. Northern Ontario Ducks Unlimited Marshes: Refugia for Leopard Frogs? CARCNET 5th Annual Meeting, Penticton, British Columbia, 22-25 September 2000.

Schueler, F. W., A. Karstad, and **A. Zieleman.** 2010. Results of the 30 Years Later Expedition (II): trip to Cochrane District, Ontario, 5-15 May 2010. 80 pages, search engine identification string: plergsojiwoitjgdsrlkvndso'vndo;ivjs[rihogarpoihfase http://fragile inheritance.org/documents/RESULTS_Cochrane.pdf

Seburn, D. C., and **C. N. L. Seburn.** 1997. Northern Leopard Frog survey of northern Ontario: report on a declining amphibian. Unpublished report to the Wildlife Assessment Unit of the Ontario Ministry of Natural Resources, Thunder Bay.

Literature Cited

Altig, R. 1970. A key to the tadpoles of the continental United States and Canada. Herpetologica 26 : 180-207.

Austin, J. D., S. C. Lougheed, L. Neidrauer, A. A. Chek, and **P. T. Boag.** 2002. Cryptic lineages in a small frog: the post-glacial history of the spring peeper, *Pseudacris crucifer* (Anura: Hylidae). Molecular Phylogenetics and Evolution 25: 316-329.

Ashton, R. E., S. I. Guttman, and **P. Buckley.** 1973. Notes on the distribution, coloration, and breeding of the Hudson Bay Toad, *Bufo americanus copei* (Yarrow and Henshaw). Journal of Herpetology 7: 17-20.

Bider, J.-R., and **S. Matte.** 1996. The Atlas of amphibians and reptiles of Québec. St. Lawrence Valley Natural History Society and Ministère de l'Environnement et de la Faune du Québec. Québec. 106 pages.

Bleakney, J. S. 1954. Range extensions of amphibians in Eastern Canada. Canadian Field-Naturalist 68: 165-171.

Bleakney, J. S. 1958. A zoogeographical study of the amphibians and reptiles of Eastern Canada. National Museum of Canada, Bulletin 155 (Biological Series 54). 119 pages.

Bleakney, J. S. 1959. *Thamnophis sirtalis sirtalis* (Linnaeus) in Eastern Canada, redescription of *T. s. pallidula* Allen. Copeia 1959: 52-56.

Brooks, R. J., D. Strickland, and **R. J. Rutter.** 2003. Reptiles and Amphibians of Algonquin Provincial Park. Friends of Algonquin Park, Whitney, Ontario. 48 pages.

Champagne, P. 1982. Morphologie littorale de la baie de Rupert. Le Naturaliste Canadien 109: 375-384.

Conant, R., and **J. T. Collins.** 1998. A field guide to Reptiles and Amphibians of Eastern and Central North America, 3rd edition. Houghton Mifflin Company. Boston and New York, U.S.A. xviii + 616 pages.

Cook, F. R. 1964. A northern range extension for *Bufo americanus* with notes on *B. americanus* and *Rana sylvatica.* Canadian Field-Naturalist 78: 65-66.

Cook, F. R. 1983. An analysis of toads of the *Bufo americanus* group in a contact zone in Central Northern North America. Publications in Natural Sciences (3). Natural Museum of Natural Sciences, National Museum of Canada. Ottawa, Canada. 89 pages.

Cook, F. R. 1984. Introduction to Canadian amphibians and reptiles. National Museum of Natural Sciences, National Museums of Canada. Ottawa, Canada. 211 pages.

Desroches, J.-F., and **D. Rodrigue.** 2004. Amphibiens et reptiles du Québec et des Maritimes. Éditions Michel Quintin. Québec. 288 pages.

Dole, J. W. 1971. Dispersal of recently metamorphosed Leopard Frogs, *Rana pipiens*. Copeia 1971: 221-228.

Ernst, C. H., and **E. M. Ernst.** 2003. Snakes of the United States and Canada. Smithsonian Books, Washington and London. 668 pages.

Fortin, C. 2006. Extension de l'aire de répartition nordique de la salamandre à deux lignes. Bulletin de la Société de géographie du Québec 1 : 5-7.

Fortin, C. 2005. Sortie herpétologique sur la Côte-Nord et au Labrador : de Natashquan à St. Lewis. Le Naturaliste canadien 129 : 50-56.

Fortin, C., M. Ouellet, and **M.-J. Grimard.** 2003. La rainette faux-grillon boréale : présence officiellement validée au Québec. Le Naturaliste Canadien 127: 71-75.

Gaige, H. T. 1932. The status of *Bufo copei.* Copeia 1932: 134.

Gregory, P. T., and **K. W. Larsen.** 1993. Geographic variation in reproductive characteristics among Canadian populations of the common garter snake (*Thamnophis sirtalis*). Copeia 1993: 946-958.

Hoffman, E. A., and **M. S. Blouin.** 2004. Evolutionary history of the Northern Leopard Frog: Reconstruction of phylogeny, phylogeography, and historical changes in population demography from mitochondrial DNA. Evolution 58: 145–159.

Kamstra, J. 1983. Northern range extension of the Two-lined Salamander, *Eurycea b. bislineata,* in Ontario. Canadian Field-Naturalist 97: 116.

Koonz, W. 1992. Amphibians in Manitoba. Pages 19-20 *in* Declines in Canadian amphibian populations: Designing a national monitoring strategy. *Edited by* C. A. Bishop and K. E. Pettit. Canadian Wildlife Service Occasional Paper 76. Ottawa, Canada.

Lacasse, R. 1983. Baie James, une épopée. Éditions Libre Expression, Québec. 653 pages.

Larsen, K. W., P. T. Gregory, and **R. Antoniak.** 1993. Reproductive ecology of the common garter snake *Thamnophis sirtalis* at the northern limit of its range. American Midland Naturalist 129: 336-345.

Lee-Yaw, J. A., J. T. Irwin, and **D. M. Green.** 2008. Post-glacial range expansion from northern refugia by the wood frog, *Rana sylvatica*. Molecular Ecology 17: 867-884.

Logier, E. B. S., and **G. C. Toner.** 1961. Check list of the amphibians and reptiles of Canada and Alaska. The Royal Ontario Museum Contribution 53, Toronto. 92 pages.

Lowcock, L. A., H. Griffith, and **R. W. Murphy.** 1992. Size in relation to hybridity, ploidy, and breeding dynamics in Central Ontario populations of the *Ambystoma laterale-jeffersonianum* complex. Journal of Herpetology 26: 46-53.

MacCulloch, R. D. 2002. The ROM field guide to amphibians and reptiles of Ontario. Royal Ontario Museum and McClelland & Stewart Ltd., Toronto. 168 pages.

MacCulloch, R. D., and **J. R. Bider.** 1975. New records of amphibians and Garter Snakes in the James Bay area of Québec. Canadian Field-Naturalist 89: 80-82.

Maunder, J. E. 1997. Amphibians of Newfoundland and Labrador: status changes since 1983. Pages 93-99 *in* Amphibians in decline: Canadian studies of a global problem. *Edited by* D. M. Green, Herpetological Conservation, Volume 1. Society for the Study of Amphibians and Reptiles. St. Louis, Missouri. USA.

McCoy, C. J., and **C. J. Durden.** 1965. New distribution records of amphibians and reptiles in Eastern Canada. Canadian Field-Naturalist 79: 156-157.

Moriarty, E. C., and **D. C. Cannatella.** 2004. Phylogenetic relationships of the North American chorus frogs (*Pseudacris*: Hylidae). Molecular Phylogenetics and Evolution 30: 409-420. http://www.bio.fsu.edu/chorusfrog/Moriarty%20and%20Cannatella%202004.pdf

Moriarty Lemmon, E., A. R. Lemmon, J. A. Lee-Yaw, J. T. Collins, and **D. C. Cannatella.** 2007. Phylogeny-based delimitation of species boundaries and contact zones in the trilling chorus frogs (*Pseudacris*). Molecular Phylogenetics and Evolution 44: 1068–1082. http://www.bio.fsu.edu/chorusfrog/Lemmon%20et%20al%202007a.pdf

Ouellet, M., C. Fortin, and **M.-J. Grimard.** 2009. Distribution and habitat use of the Boreal Chorus Frog (*Pseudacris maculata*) at its extreme northeastern range limit. Herpetological Conservation and Biology 4: 277-284.

Pace, A. E. 1974. Systematic and biological studies of the leopard frogs (*Rana pipiens* complex) of the United States. Miscellaneous Publications, Museum of Zoology, University of Michigan 148:1-140.

Petranka, J. W. 1998. Salamanders of the United States and Canada. Smithsonian Institution Press, Washington and London, USA. 587 pages.

Rye, L. A. 2000. Analysis of areas of intergradation between described. subspecies of the common garter snake, *Thamnophis sirtalis*, in Canada. unpublished Ph.D. thesis, University of Guelph. ix + 107 pages.

Schueler, F. W. 1973. Frogs of the Ontario Coast of Hudson Bay and James Bay. Canadian Field-Naturalist 87: 409-418.

Schueler, F. W. 1975. Geographic variation in the size of *Rana septentrionalis* in Québec, Ontario, and Manitoba. Journal of Herpetology 9: 177-185.

Schueler, F. W. 1982. Geographic variation in skin pigmentation and dermal glands in the Northern Leopard Frog, *Rana pipiens.* Publications in Zoology, National Museum of Natural Sciences, National Museums of Canada 16: 1-80.

Schueler, F. W., and **F. R. Cook.** 1980. Distribution of the middorsal stripe dimorphism in the wood frog, *Rana sylvatica*, in eastern North America. Canadian Journal of Zoology 58: 1643-1651.

Schueler, F. W., and **A. R. Karstad.** 1975. Notes on the distribution and habitat of amphibians and turtles in northwestern Québec. Canadian Field-Naturalist 89: 57-59.

Schueler, F. W., D. H. Baldwin, and **J. D. Rising.** 1974. The status of birds at selected sites in Northern Ontario. Canadian Field-Naturalist 88: 141-150.

Seburn, D., and **C. Seburn.** 2000. Conservation priorities for the amphibians and reptiles of Canada. World Wildlife Fund Canada and Canadian Amphibian and Reptile Conservation Network. 92 pages.

Société d'énergie de la Baie James. 1978. Connaissance du milieu des territoires de la Baie James et du Nouveau-Québec. Société d'énergie de la Baie James, Service Environnement, Québec. 297 pages.

Weller, W. F., and **D. M. Green.** 1997. Checklist and current status of Canadian amphibians. Pages 93-99 *in* Amphibians in decline: Canadian studies of a global problem. Herpetological Conservation, Volume 1, *Edited by* D. M. Green, Society for the Study of Amphibians and Reptiles. St. Louis, Missouri. USA.

Williams, M. Y. 1920. Notes on the fauna of the Moose River and the Matagami and Abitibi tributaries. Canadian Field-Naturalist 34: 125.

Wright, A. H., and **A. A. Wright.** 1949. Handbook of frogs and toads of the United States and Canada, Third edition. Cornell University Press, Ithaca and London. 640 pages.

Received 19 March 2005
Accepted 17 November 2010

News and Comment

Annual Meeting of the Alliance of Natural History Museums of Canada, October 2010

Leaders of Canada's major natural history museums attended the annual meeting of the Alliance of Natural History Museums of Canada (ANHMC) in October 2010. The network was created in 2003 to enhance collaborative work in the areas of research, collections development, and education about the natural environment.

The ANHMC's 16 members from west to north to east are: the Royal British Columbia Museum, Vancouver Aquarium, Royal Alberta Museum, Royal Tyrrell Museum of Palaeontology, Yukon Beringia Interpretive Centre, Prince of Wales Northern Heritage, Royal Saskatchewan Museum, Manitoba Museum, Royal Ontario Museum, Canadian Museum of Nature, Toronto Zoo, Montreal's Nature Museums (Biodôme, Insectarium, Botanical Gardens and Planetarium), Redpath Museum (Montreal), New Brunswick Museum, Nova Scotia Museum of Natural History, and The Rooms Provincial Museum, Newfoundland and Labrador.

These institutions are responsible for preserving the record of Canada's natural history through time. Together, member museums safeguard more than 19 million catalogued specimens of plants, animals, minerals and fossils collected over 150 years. The purpose of the national collections strategy is to ensure that this crucial record is complete and is preserved in perpetuity.

Dr. Wayne Maddison, an evolutionary biologist at the University of British Columbia (UBC) and director of Canada's newest natural history museum, is the distinguished recipient of the 2010 Bruce Naylor Award. This national award was presented on 26 October in the Speaker's Reception Room in the Centre Block of Parliament Hill by the ANHM Canada. It recognizes exceptional contributions to the museum-based study of natural history in Canada. The Bruce Naylor Award is named for the former director of the Royal Tyrrell Museum of Palaeontology. Deceased in 2007, Dr. Naylor had also served as president of the ANHMC.

Dr. Maddison heads the new Beaty Biodiversity Museum in Vancouver, British Columbia, where he recently presided over the museum's public opening on 16 October 2010. This administrative post is the latest step in his multi-faceted career as a professor, teacher and world expert on jumping spiders, a group with more than 5000 species known to science. Maddison has published over 20 scientific papers on the taxonomy, systematics and evolution of jumping spiders, which are known for their acute vision. In 2008, he discovered dozens of new species during field work in Papua New Guinea.

"He's is not only an inspirational teacher and natural historian, but also someone who has contributed to the way that we talk about evolutionary biology," explains Dr. Sarah Otto, a colleague and Professor of Zoology at the University of British Columbia.

Maddison has shared his passion for understanding evolution and biodiversity in numerous ways. He has developed some fundamental computer programs and tools used by biologists for phylogenetics, the study of evolutionary relatedness among living things. He is also one of the founders of the encyclopedic Tree of Life project (http://tolweb.org/tree). With more than 10 000 Web pages, this award-winning project provides information about biodiversity, the characteristics of different groups of organisms, and their evolutionary history.

His path as a naturalist and scientist began in his youth. "I remember paying a lot of attention to bugs, salamanders and other critters as a child, with my brother," he remarks. "When I was 13, I found an especially entrancing jumping spider. I kept it alive for months, and started learning about others. I haven't stopped since."

Undergraduate studies at the University of Toronto were followed by a doctorate at Harvard University. From there Maddison eventually landed at the University of Arizona, where he established his credentials as an evolutionary biologist who studied jumping spiders as a way to approach scientific questions about systematics and the interrelationships of living things.

In 2003, Maddison relocated to Vancouver as a professor at the University of British Columbia and was awarded a Canada Research Chair in the Departments of Zoology and Botany. At UBC, he spearheaded the development of the Beaty Biodiversity Museum, which houses 2 million specimens, including one of only two blue whale skeletons on display in Canada.

"I've been associated with museums since high school, and I've often felt the joy of stumbling on important specimens in their collections. I always felt that I was sifting through treasures of the natural world," he notes in reflecting on his new position at the Beaty Museum. "When UBC decided to consolidate our collections and open a public natural history museum, I stepped forward to help with this important effort to study biodiversity, to archive it, and to tell the public of its wonders."

The Ottawa Field-Naturalists' Club Awards for 2009, presented April 2010

Ken Allison, Irwin Brodo, Julia Cipriani, Christine Hanrahan, and Eleanor Zurbrigg

At the Club's Annual Soiree, held on 17 April 2010, at St. Basil's Church in Ottawa, awards were once again given to members, and one non-member, who distinguished themselves by accomplishments in the field of natural history and conservation, or by extraordinary activity within the Club. The following five citations for those who received an award were read to the members and guests assembled for the event.

Honorary Member: Dr. Fenja Brodo

This award is presented in recognition of outstanding contributions by a member or non-member to Canadian natural history or to the successful operation of the Club. Usually people awarded an honorary membership have made extensive contributions over many years.

Dr. Fenja Brodo has served the natural history community on many fronts. As an English major at City College in New York city, Fenja took a biology course for non-science students led by Alexander Klots, the author of the first Peterson guide to butterflies. In her own words, "She was hooked." She graduated in biology in 1958. In the mid-sixties she earned a masters degree at University of Kansas with a study of crane flies under the guidance of the well-known crane fly expert, George Byers. After the Brodos moved to Ottawa, Fenja pursued her studies at Carleton University. The subject of her 1984 doctoral thesis was an Arctic group of crane flies. She has worked with the Geological Survey doing insect inventories on Ellesmere Island as part of a team of field biologists. Fenja is presently a Research Associate at the Canadian Museum of Nature and continues her taxonomic research at her well-equipped lab at home. Over the past 45 years, she amassed a large insect reference collection which she enthusiastically shares.

Fenja has been active in the club since 1966 when she joined as a family member. She led her first outing, a general insects field trip, on July 15, 1967. After making her skills as an editor known, Fenja was asked to take over as the fourth editor of *Trail and Landscape* (T&L) in time for the first issue of 1991. She fulfilled the role until the second T&L of 2001 when the job was handed over to Karen McLachlan-Hamilton, the current editor. Fenja did take a bit of break from T&L in the early '90s when she lived in Scandinavia.

Fenja was deeply involved with the Eastern Ontario Biodiversity Museum in Kemptville as a Board member and as a program leader. Its demise occurred despite her heroic efforts to keep it going. Thanks to her extensive network, she did find homes for the collection.

Her stint as editor of T&L heightened her interest in the Excursions and Lectures Committee. She was drawn to the possibility of adding more events to the roster. She left the editor's position armed with an enviable rolodex disguised as a recipe box which holds the names and telephone numbers of who's who of Ottawa-area and beyond naturalists. Fenja became a member of Excursions and Lectures Committee and assumed the role of Chair in 2003. She was formally recognized in that role in 2004. In 2009 Fenja handed that committee over to Christine Wong and accepted the nomination of Vice President for 2010. Fenja remains active in the Excursions and Lectures Committee, hosting planning meetings to share information and generate ideas.

It is her mission to spark children's interest in the natural world. Fenja is quick to credit the efforts and contributions of others and demonstrates a great respect for and curiosity about what others have to say. She radiates contagious passion for the natural world, especially one populated with crane flies in any state of their development. Whether she is leading or participating in an outing, she brings enthusiasm and excitement and takes delight in sharing her knowledge. These characteristics may be witnessed if you happen to be a participant with Fenja in the Annual Butterfly Count.

Her husband, Ernie, describes Fenja as a "wonderful teacher". An indication of her capacity to influence others is reflected in the quote Barry Bendell, a seniors' leader with Macoun, left on the Macoun site from his days in that club, "I can clearly remember the first larva I ever saw. Fenja Brodo caught it and showed it to me. Then, what I had only known from books became a living, breathing thing. I was not learning what a dragonfly larva looked like. I already knew that. Instead the larva became part of my own experience in a way that things in books could never be."

Thank you, Fenja. It is a pleasure and privilege to award Fenja Brodo an Honorary Membership in the Ottawa Field-Naturalists' Club.

(Written by Julia Cipriani, based on an interview with and input from Fenja Brodo, revisions and additions received from Irwin Brodo.)

Honorary Member: Dr. Paul M. Catling

This award is presented in recognition of outstanding contributions by a member or non-member to Canadian natural history or to the successful operation of the Club. Usually people awarded an honorary membership have made extensive contributions over many years.

Dr. Paul M. Catling, one of Canada's most distinguished plant taxonomists, is a man of many talents and interests. Many who know him as a botanist are surprised to learn of his accomplishments in entomology, and the reverse is also true. He is an outstanding speaker and popularist, authoring dozens of articles of general interest on a variety of topics.

Dr. Catling received his doctorate in plant systematics from the University of Toronto in 1980 and has worked as a Research Scientist with Agriculture and Agri-Food Canada (AAFC) ever since. He is the Curator of the Agriculture Canada herbarium, Canada's largest plant collection, with over a million flowering plant specimens. Dr. Catling has authored over 200 refereed scientific articles and co-authored several books. He is internationally known for his work on the classification and ecology of plants and insects, and is widely recognized as an expert on hybridization and pollination biology. Much of Dr. Catling's work at AAFC has involved economically important plants, particularly aquatics, forages, berry crops, and invading alien weeds. He has also worked towards the protection of economically important threatened native Canadian plants, and has participated in national and international committees concerned with plant conservation. Dr. Catling has served as President of the Canadian Botanical Association, and he received their prestigious George Lawson medal in 2005 for his contributions to Canadian botany. He has been an Adjunct Professor and a Member of the School of Graduate Studies at the University of Ottawa since 1989. He has received awards for education in botany and for work on Canadian endangered species, and several species have been named in his honour.

Members of a club such as the OFNC couldn't find a better role model. Dr. Catling is one of eastern Canada's most productive and active field naturalists with an unsurpassed diversity of interests, producing (and publishing) hundreds of studies on alvars, orchids, aquatic plants, invasive weeds, birds, reptiles (especially snakes), lepidoptera, dragonflies and beetles and more. He is an inspirational example of broad-mined curiosity and investigation in an era of sadly narrow specialization.

Paul's interests in local and Canada-wide conservation are no less impressive. He has been a long-time, significant voice in conservation initiatives in Ottawa, Ontario and across Canada through participation in COSEWIC (Committee on the Status of Endangered Wildlife in Canada), with the Nature Conservancy of Canada (as a Board member) and through involvement with regional organizations such as the Ottawa Field-Naturalists' Club (OFNC) and the Federation of Ontario Naturalists. Paul has always been ready to provide informed assistance to those seriously interested in the study, appreciation and most importantly, the *conservation* of natural features and habitats, regardless of their professional status or position.

An active member of the OFNC since 1982, Paul served on Council in 1980s and was Vice-President from 1982 until 1984. He was a member of both Conservation and Excursions & Lectures committees and has been an Associate Editor (Botany) of *The Canadian Field-Naturalist* since 1997. He contributed many articles to club publications and acted as a leader in many OFNC excursions. Paul was much involved in major conservation issues such as the Alfred Bog and the Burnt Lands.

Paul's generosity with time, expertise and resources extends back to his student days in Toronto and Algonquin Park, and continues today. He works formally and informally with many such associates in his scientific and conservation work. He offers an exceptional example of the appropriate application of superior field-based science in the promotion and achievement of significant conservation goals. His efforts continue to provide substantial, permanent contributions to the appreciation and protection of native Canadian biodiversity and inspire others to do likewise.

It is a pleasure and privilege to award him an Honorary Membership in the Ottawa Field-Naturalists' Club.

(Written by Irwin M. Brodo, based on material from NRC Research Press, and comments from Dan Brunton and Francis Cook.)

The George McGee Service Award: Gretchen and Tony Denton

This award is given in recognition of members who have contributed significantly to the smooth running of the Club over several years.

Gretchen and Tony Denton have been volunteering at the Fletcher Wildlife Garden (FWG) for at least 12 years. Their dedication to the project is remarkable and there is little that they have not turned their hands to over this time. Soon after retiring, Tony was inspired to begin volunteering after participating in a spring birding tour of the garden led by Jeff Harrison. Gretchen joined him as a volunteer very soon thereafter.

Gretchen is a mainstay of the volunteer force at the FWG. When we need FWG volunteers to help out with events, be it the Wildlife Festival exhibit at Billings Bridge, the Annual Christmas Party at the garden, or any other similar event, Gretchen is the one who con-

tacts and coordinates the volunteers. She is also a regular part of the Backyard Garden (BYG) group. Tony is the lead on buckthorn control, as well as being generally, a very handy person who helps out with tool maintenance, building, and repair jobs. Take a look at the bench dedicated to Dale Crook in the BYG and the bench in the Butterfly Meadow. Tony is largely responsible for the design and creation of both.

Some little while after joining the FWG volunteers, Tony began working with Dale Crook to remove the invasive buckthorn shrubs. When Dale became too ill to continue, Tony took over and has been working on this from spring through fall for at least nine years. Thanks to his efforts we have seen a great reduction in this species at the garden. Tony is very good at rounding up willing volunteers and he often has a good group on Friday mornings to help him. He also comes in at other times to work on the buckthorn project, sometimes for long hours alone. Visitors often stop to ask what he is doing and Tony is always willing to take a break and explain. He emphasizes the importance of recognizing this serious invasive shrub and has used his hands-on knowledge of buckthorn control to help others, such as community groups, in tackling this problem.

Gretchen too, has learned a lot about invasive species through her work at FWG, and like Tony, has taken this knowledge and helped others to respond to the threat of problem species. She has commented that in her own neighbourhood she has spread the word about the problems presented by species such as garlic mustard, dog-strangling vine, and of course, buckthorn.

We maintain two bird feeders at FWG during the winter and Tony ensures that they are always filled so no bird has to go hungry. He also performs regular maintenance on the feeders, and when one was vandalized, he built and installed a new one.

With all that Gretchen and Tony do for the FWG, it is good to know that they believe they receive as much as they give. One of the perks of volunteering at the garden is listening to birds and watching wildlife as they work. They definitely enjoy the good company of fellow volunteers at the garden, and appreciate the relaxed atmosphere the FWG provides.

We believe that both Tony and Gretchen have made remarkable contributions, both in terms of service to the club through their work at FWG, and to the furthering of knowledge of invasive species through their outreach work in their neighbourhood and beyond. For all of these reasons, the OFNC is pleased to present this award to Gretchen and Tony Denton.

(Written by Christine Hanrahan)

Conservation Award – Non-Member: Meredith Brown

The Conservation Award – Non-Member is given in recognition of an outstanding contribution by a non-member in the cause of natural history conservation in the Ottawa Valley.

Meredith Brown is the Executive Director of Ottawa Riverkeeper. This organization is "an independent voice for the Ottawa River, working to protect, promote and improve its ecological health and future". Ottawa Riverkeeper was founded in 2001. In its relatively short existence, Ottawa Riverkeeper has almost single-handedly raised the profile of the Ottawa River and its conservation needs to extraordinary heights. This was particularly evident when faulty City of Ottawa structures poured over a billion litres of raw sewage into the river in July 2009. The issue was politically charged and could easily have spun out of control as various levels of government fought over who was most responsible. Meredith Brown was a voice of reason throughout the crisis, being called upon by the public and the media to sort the science from the hyperbole. This resulted in a calm, fact-based response to a long-standing problem, and a major commitment of funds from all levels of government for the enhancement of the quality of the Ottawa River. Meredith played a major role in keeping the public debate on the river's needs firmly science based. Regionally and nationally significant natural environment features and functions across the entire lower Ottawa River watershed have benefited as a result.

We believe that Meredith has made an outstanding contribution in the cause of natural history conservation in the Ottawa Valley. After all, the Valley would not exist without the river which Ottawa Riverkeeper works to protect. For this reason, the OFNC is pleased to present this award to Meredith Brown.

(Written by Ken Allison, based on input from Dan Brunton)

Mary Stuart Education Award: Ottawa-Carleton Wildlife Centre (Donna DuBreuil)

The Mary Stuart Education Award was established to recognize members, non-members or organizations for their outstanding achievements in the field of natural history education in the Ottawa Region.

The award for 2009 is presented to the Ottawa-Carleton Wildlife Centre (OCWC) and its president, Donna DuBreuil, for their efforts to educate people about wildlife and to help foster an appreciation for the natural world as well as to give people the basic tools to solve human/wildlife conflicts in a humane and cost-effective way.

First and foremost, this award recognizes the Centre's successful Wildlife Education School Program, launched some years ago to help children take the first

crucial steps in conservation, coexisting and appreciating wildlife in their own backyard. This education program is both unique in providing a presence in Ottawa area classrooms (from grades Junior Kindergarten to eight) and exceptionally timely in its mission to reconnect children to the natural world. A large part of the program's success results from the special perspective that Centre takes into classrooms. Not only are Donna DuBreuil and Kate MacNeil, the Education Coordinator, passionate about wildlife but they also have firsthand experience gained during years of doing wildlife rehabilitation. Their personal accounts of amazing animal stories intrigue students and help them relate to wildlife.

Secondly, this award recognizes the outstanding efforts of the OCWC and Donna and Gary DuBreuil to raise awareness of the general public and city officials as well, on the premise that many instances of human/wildlife conflict can be avoided if there is a better understanding and appreciation for wildlife so that actions are taken to mitigate the impact of development and human encroachment into wildlife habitat. They maintain an informative wildlife website on how to deal with wildlife problems, and produce an informative newsletter available in hard copy and on their website. They work with individuals and community groups to resolve situations of conflict with wildlife, as for example, working with the Graham Creek community on problem beaver. Our club has also sought advice from the OCWC — when a young beaver turned up in the Amphibian Pond at the Fletcher Wildlife Garden and began cutting trees, making a dam and a bank burrow, we were not sure how to deal with this situation for various reasons. Donna provided a lot of support, valuable help, and information.

Donna writes many articles on wildlife in Ottawa community newspapers. Donna with The Greenbelt Coalition is working to raise awareness of City of Ottawa officials on the need for a comprehensive wildlife strategy focused on development planning and public education as a necessary component in the face of urban development which continues to move out into wildlife habitat, and that community consultation needs to be part of its development to educate new rural dwellers on wildlife around their new homes.

The OFNC is pleased to present the Mary Stuart Education Award to the Ottawa-Carleton Wildlife Centre and its president, Donna DuBreuil.

(Written by Eleanor Zurbrigg with review comments from Christine Hanrahan)

The Evolution of Biological Societies in Alberta

LU CARBYN[1], ROBIN LEECH[2,4], and GARY ASH[3,4]

[1] Department of Renewable Resources, University of Alberta, Edmonton, Alberta T6G 2H1 Canada; and Canadian Wildlife Service, Twin Atria Building, 200 - 4999 - 98 Avenue NW, Edmonton, Alberta T6B 2X3 Canada
[2] Research Associate, Royal Alberta Museum, 12845-102 Avenue NW, Edmonton Alberta T5N 0M6 Canada
[3] Golder Associates Ltd., #300, 10525-170 Street NW, Edmonton, Alberta T5P 4W2 Canada
[4] P.BIOL. [Professional Biologist]

Carbyn, Lu, Robin Leech, and Gary Ash. 2010. The evolution of biological societies in Alberta. Canadian Field-Naturalist 124(4): 321-329.

At present, four organizations serve biologists in Alberta: The Alberta Chapter of the Wildlife Society (ACTWS), The Alberta Native Plants Council (ANPC), The Alberta Society of Professional Biologists (ASPB), and The Canadian Society of Environmental Biologists (CSEB). Only the ASPB is a professional regulatory organization, two of the others (CSEB and ACTWS) have their origins in the Canadian Society of Wildlife and Fisheries Biologists (CSWFB) while ANPC is a non-regulatory society with independent origin. A fifth organization, the Canadian Chapter of Society for Conservation Biology, is being organized through initiatives resulting from the 24th International Congress for Conservation Biology, held in Edmonton in July 2010. Its role in Canada is not yet defined.The first biological society to function in Alberta was a chapter of The Canadian Society of Wildlife and Fisheries Biologists (CSWFB). After 10 years this organization morphed into the CSEB when the hopes of creating a professional status faded. This change forced the CSPB towards forming a professional voice on resource use, and towards a communication medium for biological resource management. Biological consulting firms proliferated in the late 1960s and early 1970s, coinciding with provincial and federal governments forming departments of the environment. Pressures from these events created a perceived need by some biologists for a self-regulating, professional organization, which comes under provincial jurisdiction. To this end, the Alberta Society of Professional Biologists (ASPB) formed in 1975, and in 1991 received its Professional Biologist title status (P.Biol.) for members under the Societies Act of Alberta. The Alberta Chapter of The Wildlife Society (ACTWS) was formed in 1989; its focus was on research, science and wildlife management.

Key Words: Biological Societies, Alberta Chapter of the Wildlife Society (ACTWS), The Alberta Native Plants Council (ANPC); The Alberta Society of Professional Biologists (ASPB), and The Canadian Society of Environmental Biologists (CSEB), Alberta.

On the occasion of the 22nd anniversary of The Alberta Chapter of The Wildlife Society (established in 1989), it is worthwhile to reflect on its origins. The parent society – The Wildlife Society – has had a much longer history with its formation in the United States in 1937. North American biologists, mainly wildlife and fisheries biologists, from both Canada and the United States, had formed a professional bond early its history of development. Much of the leadership came from the Americans, although numerous Canadians also served in various executive positions from time to time. The Alberta Chapter of The Wildlife Society was an offshoot of the parent organization. It had its origins in the diverging interests of biologists with different agendas and differing perspectives on professionalism. To better understand that path, it is necessary to look at the bigger picture.

Currently there are four organizations that specifically serve biologists in Alberta. These are the Canadian Society of Environmental Biologists (CSEB), The Alberta Society of Professional Biologists (ASPB), The Alberta Chapter of The Wildlife Society (ACTWS), and the Alberta Native Plants Council (ANPC).

In addition to specific biological societies, there are a number of conservation societies in Alberta that serve specific functions with broad based support from biologists. Some of the larger organizations are AWA (Alberta Wilderness Society); FAN (Federation of Alberta Naturalists – recently changed its name to NA – Nature Alberta); ALMS (Alberta Lake Management Society); CPAWS (Canadian Parks and Wilderness Society); Alberta Lepidopterist's Guild; Calgary Zoological Society; and the Soil and Water Conservation Society.

The CSWFB was established in 1958 and was a Canada-wide organization. Membership dues in 1967 were $7.00 for regular members and $1.00 for students. The pan-Canadian Society consisted of six regional chapters (Maritimes, Quebec, Ontario, Prairie Provinces, British Columbia and the Territories). The membership was small but relatively active, and there was considerable cohesion countrywide. Despite the absence of computers, fax machines and photocopy machines, communication among members was very effective. The society had a strong traditional base in the classical disciplines of wildlife and fisheries biology. Its members came from government agencies and universities. There were few, if any, environmental consultants active at the time.

The founding members of CSWFB stated that the aims of the Society were "To establish and maintain the highest possible professional standards in wildlife and fisheries research and management, and to develop all phases of wildlife and fishery management along sound lines in relation to proper land use and in accordance with the best interests in the community."

Consultants burst onto the scene in the late 1960s and early 1970s. It was also a time that federal and provincial governments began to establish departments of the environment, and laws were enacted to cover environment and resource protection.

With the emergence of laws protecting the environment, the growth of private initiatives and environmental consultants was inevitable. This brought new, evolutionary initiatives to the forefront. The once close-knit Canadian Society of Wildlife and Fisheries Biologist began to fall apart in the late 1960s. It was noted in 1968 that the "decrease in growth of the society, its failure to attract provincial and federal resource biologists and the gradual evolution of the society away from one seeking to create professional status, to one attempting to providing a professional voice, on topics of resource use and provide communication on these and other topics, between Canadian professional resource biologists, was discussed" (*Canadian Wildlife and Fisheries Newsletter Bulletin* 25(1)).

In immediate terms, the name of CSWFB was changed to the Canadian Society of Environmental Biologists (CSEB), and that was only the beginning of a process that led to the formation of other societies. The old Society of Canadian Wildlife and Fisheries Biologists was clearly in a crisis mode. This was an unfortunate circumstance since it served wildlife and fisheries biologists well, from east to west and south to north. The old organization (CSWFB) adopted a new constitution and was renamed as the Canadian Society of Environmental Biologists (CSEB) in recognition of the broader scope of practice of biologists in Canada. This change did not satisfy or accommodate all biologists in Alberta.

Much debate and considerable turmoil existed in the different orientations within the professional community. Chief architects at the time, who prompted change and demanded a more structured professional group, were government administrators and individuals in newly established consulting firms. Others were not happy with a change from classical wildlife and fisheries orientation to a "watered down" environmental label. These were the more conservative elements among the professionals. Nevertheless, the CSEB survived, but only as a much smaller national organization with generally weaker provincial chapters.

Two societies, the ASPB and ACTWS, staked out their claims for action in the provincial scene. In this regard, Alberta became a leader on the national scene. So how was that possible? In reality, it was not at the expense of CSEB, an organization that proved to have a remarkable level of survival. That was possible only because of some dedicated individuals who volunteered their time and resources to a cause they strongly believed in.

Today the CSEB has a membership of over 200 biologists from coast to coast in Canada. It has sponsored numerous symposia on a variety of national issues. A list of publications resulting from these symposia is provided in Appendix A. The society also publishes a quarterly Newsletter/Bulletin, which includes regional news of interest to biologists, biological articles submitted by its members, and other information that would be of interest to environmental biologists. In more recent times all the CSEB symposia publications were made available in digital format only.

Provincial organizations within CSEB are quite variable and, generally, not as strong as the national organization. CSEB membership ranges broadly within the disciplines of environmental biology including fisheries and wildlife biology, forestry, environmental toxicology, limnology, plant science and zoology. For more details visit the website: http://www.cseb-scbe.org. With these changing trends, there were also competing visions of what professional organizations should be about.

In the early 1970s, the struggle for influence and membership between the different organizations serving biologist was very pronounced and resulted in heated debates. On the one hand, we had those who believed in environmentally oriented actions. They urged biologists to speak up on environmental issues. Principal proponents of this view were University of Alberta and University of Calgary professors, most notably Drs David Boag, Bill Fuller, Tim Myres and Joe Nelson.

Another group felt that professional biologists should form a "society" to protect professionalism and to establish an organization with a prime focus: to evolve as a self-regulating body in Alberta. Such a society would be committed to promoting excellence in the practice of biology. The society that evolved out of this initiative was The Alberta Society of Professional Biologists (ASPB) with a 2010 membership approaching 1000 biologists (Table 1) (actual active memberships in November 2010 stood at 894). The enthusiastic province-wide participation in this membership is remarkable considering the high annual membership dues.

The principal leader in the movement towards establishing a provincially incorporated society, a professional regulatory organization, equivalent to those of the engineers, agrologists, veterinarians and others, was the then Alberta Director of Wildlife and Fisheries, Dr. Stu Smith. Dr. Robin Leech, P.Biol., served as the first Secretary for the ASPB, working directly with the late Stu Smith, P.Biol., Don Dabbs, P.Ag., P.Biol., and others who helped to register the ASPB as a legal society in 1975. The ASPB was registered as a professional regulatory organization in 1991 under the Professional and Occupational Associations Registration Act (POARA) of Alberta, permitting its members to have the exclusive right to title of Professional Biologist, or P.Biol., but not with exclusive right of practice (as with P.Eng.).

The ASPB publications are listed in Appendix B.

On the provincial scene, the ASPB has grown at a remarkable rate and has established a very effective society with a well-funded infrastructure. The website is www.aspb.ab.ca, and direct contact can be made through http://pbiol@aspb.ab.ca. There are major difference between the ASPB and CSEB. The main one is that the ASPB is a provincially regulated organization (PRO) with legal status and exclusive right to title (Professional Biologist or P.Biol.) for its members, whereas the CSEB is an interprovincial organization with no provincial regulation, legal status or title for its members.

The objectives of the ASPB are as follows:

1. To promote high standards of professional competence and ethics in its membership and in biologists at large;
2. To provide a mechanism through which the public of Alberta will be assured of the highest possible standards in the practice of biology;
3. To provide a common ground for Professional Biologists in all disciplines to meet and exchange views;
4. To promote education in the field of biology; and
5. To provide a recognized voice for Professional Biologists in Alberta.

Typically, the ASPB does not comment on controversial environmental issues, but rather restricts its involvement to professionalism, education and self-regulation of its members.

The 2011 membership fee for the ASPB is \$250 for a full member, Biologist-in-Training (BIT) fee is \$50. Associated Biologist fee is \$50, and Student fee is \$25. Also, there are Honorary Biologist and Temporarily Withdrawn Biologist categories.

To join the ASPB, one needs a minimum of a BSc in biology from a recognized institution, and a minimum of 3 years of recognized professional experience. ASPB provides mentoring programs for new members, job market contacts, connection to specific specialists, a practice review committee, a code of ethics, a monthly eBulletin and a three-times-per-year newsletter, BIOS. As part of the Continuing Competency Program, Edmonton and Calgary have noon or evening meetings with specialist speakers. The Annual General Meeting is held in either Calgary, Red Deer or Edmonton in concert with the Annual ASPB Conference.

ASPB has internal awards to its members. Submitted published papers and/or reports are assessed and winners receive the Peggy Thompson Awards. Another award is the J. Dewey Soper Award, which can be awarded to any Alberta biologist who has made major contributions and accomplishments (research and published results), and whose work makes a connection to the next generation of biologists.

ASPB offers scholarships to biologists. The Dr J. Allan Birdsall, P.Biol. Scholarship is for \$10,000 annually. Each of the three universities in Alberta (University of Alberta, University of Calgary and the University of Lethbridge) has an ASPB Endowed Scholarship Award of \$2500 for graduate students in the fields of biology. These are awarded annually.

On 1 April 2006, the governments of British Columbia and Alberta entered into an agreement where professionals and trades people could move from one province to the other without hindrance. This was called the Trade, Investment and Labour Mobility Agreement (TILMA). TILMA came into effect on 1 April 2009. A member in the ASPB need only show credentials and present a letter confirming good standing with ASPB, and pay the membership fee, to become a Registered Professional Biologist (R.P.Bio.) in British Columbia. The person could either maintain both professional memberships, or give one up, depending on where he or she is living and working. Membership in the Association of Professional Biologists of British Columbia (APBBC) requires that one must first be a member in good standing of the College of Applied Biology (CAB-BC): http://www.cab-bc.org. Professional Biologists in British Columbia are governed by the CAB. TILMA has caused an increase in the memberships of the ASPB and the CAB-BC, as there are many professional biologists who work regularly in both provinces. In late 2008, Lloyd Saul of ERIN Consultants Ltd, Regina, and some of his staff became interested in forming a Professional Biologists organization in Saskatchewan. Saul informs us (RL) that he has been working with the other registered professional organizations (stakeholders), but especially the Professional Agrologists, in Saskatchewan towards forming a Saskatchewan Society of Professional Biologists

And further east, in Winnipeg, Manitoba, an ASPB member, Shirley Bartz, P.Biol., Marlene Gifford, P.Biol., and previously, Don Harron, P.Biol., in Stantec in Winnipeg, have been attempting to set up a Professional Biologists organization. They, too, have been working with foresters and agrologists. Don registered an official name, Manitoba Society of Professional Biologists (MSPB). Marlene Gifford, P.Biol., and Shirley Bartz, P.Biol., are now on their own, as Don has returned to Alberta.

The aims and objectives of the modern Canadian Society of Environmental Biologists is to further the conservation of Canadian natural resources, to ensure the prudent management of these resources so as to minimize environmental effects, and to maintain high professional standards in education, research and management related to natural resources and the environment. The Canada-wide membership changes over the years 1973 to 2010 are presented in Table 2 and Figure 1. The distribution of the membership across the different regions in Canada in 2010 is listed in Table 3. The trend in the Canadian membership in the CSEB from 1973 to 2010 is given in Figure 1.

Over the years, the CSEB has been active in assessing and commenting on administrative and legislative polices and program, often controversial, which may

TABLE 1. ASPB (Alberta Society of Professional Biologists) Membership Trends

Year	Regular	Biologist in Training	Student	Honorary/ Retired/ Inactive	Total
1988	228	5	6	2	241
1989	222	4	6	2	234
1990	221	1	0	2	224
1991	249	4	5	2	260
1992	243	8	12	2	265
1993	255	5	15	2	277
1994	264	7	21	3	295
1995	281	12	28	3	324
1996	295	10	39	3	347
1997	305	18	43	23	389
1998	316	20	30	23	389
1999	333	24	28	27	412
2000	347	27	26	27	427
2001	375	35	14	14	438
2002	407	43	7	45	502
2003	438	52	5	46	541
2004	465	53	5	28	551
2005	483	60	7	35	585
2006	510	70	9	38	627
2007	564	108	18	38	728
2008	624	119	20	41	804
2009	699	134	12	42	887
2010	725	169	7	49	951

Note: Membership data since1992 were obtained from POARA Annual Reports. Data prior to 1992 were obtained from Board minutes.
Inactive and Retired members were added with Honorary in 1997.

TABLE 2. CSEB (Canadian Society of Environmental Biologists) Alberta Chapter Membership Trends.

Year	Compl./ Hon.	Associate	Library	Regular	Student	Total
1987		1	3	65	11	**80**
1988		1	5	80	18	**104**
1989						**n/a**
1990		5	6	93	11	**115**
1991		3	7	91	7	**108**
1992			4	83*	5	**92**
1993			4	86*	14	**104**
1994						**n/a**
1995		3	3	66	4	**76**
1996		3	3	71	8	**85**
1997		3	3	63	2	**71**
1998		1	2	74	3	**80**
1999		2		55	1	**58**
2000						**n/a**
2001	1		4	58	2	**65**
2002						**0**
2003		1	5	64	1	**71**
2004			4	44	2	**50**
2005						**0**
2006		1	3	49	3	**56**
2007	1		4	46	2	**53**
2008	1		4	40	4	**49**
2009						**0**
2010*	1	1	4	64	8	**78**

* 2010 membership numbers current to October 2010

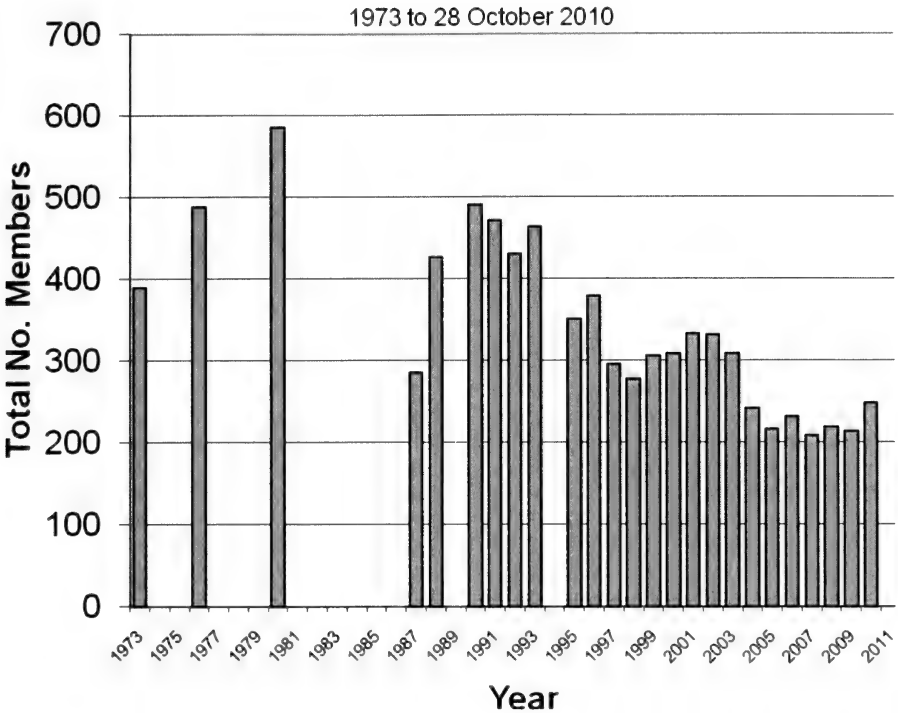


FIGURE 1. CSEB (Canadian Society of Environmental Biologists). Membership by Year (1973 to 2010).

TABLE 3. CSEB (Canadian Society of Environmental Biologists) Membership by Region and Category up to 28 October 2010

Region	Complementary/Honorary	Associate	Library	Regular	Student	Total
1 Atlantic	2	4	2	17	1	26
2 Quebec		1		15		16
3 Ontario	3	3	3	40	3	52
4 Manitoba	1			4		5
5 Sask.	1			17	1	19
6 Alberta	1	1	4	64	8	78
7 BC	2	1		31	2	36
8 Territories		1		12		13
9 USA	1		1			2
10 Foreign				1		1
Totals	11	11	10	201	15	248

have significant ecological ramifications. Some examples of this includes comments or briefs on the Federal Environmental Protection Act, the Federal Environmental Assessment process, the Federal Green Plan, the Endangered Species Act, the management of nuclear fuel wastes, and the reductions to Environment Canada budgets (including Canadian Wildlife Service).

Some think that CSEB could become a national organization that would serve to unite all professional biologists across Canada, much as the Chemical Institute for Canada (CIC) does for Canadian chemists. Although there have been several initiatives over the years to have CSEB take on the professional regulatory role (i.e., professional society similar to the ASPB), it is realized that the legislation regulating professions falls under provincial regulations, and therefore, cannot be accomplished by a national organization under its current structure.

Both organizations put on workshops and hold symposia, but CSEB lacks the financial stability, and depending on volunteer services and nation-wide scope, has a much more difficult time in serving its members. The difficulty in attracting volunteers, with all of the competing organizations and leisure activities in modern society, has limited the growth of the CSEB.

Recent developments in a Canada-wide perspective, is the possible formation of a Canadian chapter of the very active, world-wide Society for Conservation Biology (SCB). The possible merger of such an organization with CSEB might be something to be considered as a viable future endeavour. Dr. Colleen Cassady St. Claire has been involved in the initiative to possibly establish the Canadian chapter of the SBC.

The Alberta Chapter of The Wildlife Society (ACTWS) evolved when some Alberta biologists did not see either the CSEB or the ASPB as the answer. Simply put, loyal and traditional Wildlife Biologists from the old Canadian Society of Wildlife and Fisheries Biologists were not entirely happy with CSEB or ASPB at the time, and began to develop a Canadian Branch of a very well-established and functioning North American Society whose international power base was in the United States. Naturally, there were many who joined several organizations.

The Wildlife Society has a total membership of 9347 in November 2010 and by December 2010 had increased to 10 200 with 7177 located in the United States (November 2010). The Canadian total for TWS was 366. TWS has an official certification program with prescribed protocol a trademarked wildlife biologist for approval. As of November 2010, 3834 wildlife biologists in the United States held current certificaton while 181 in Canada held current certification, 39 of whom are located in Alberta. In 2010 there were five student Chapters in Canada (University of Alberta, Lethbridge Community College, Lakehead University, University of Northern British Columbia, University of Laval) and four provincial Chapters Canada-wide (British Columbia, Alberta, Manitoba and Ontario).

The Alberta Chapter of The Wildlife Society (ACTWS) and the CSEB have less rigid entrance requirements and much lower annual fees than does the ASPB. ACTWS is very much oriented towards research and management of wildlife resources and wild lands. It retained some of the old CSWFB perspectives, but added many new dimension towards its sphere of involvement. One of the most notable dimensions is the holding of effective annual meetings in the province, and more than any other professional group, has fostered the development of student participation. The society annually has granted the prestigious William Rowan award to an outstanding biologist who has made major contributions to the science and management of wildlife resources. The Chapter in 2010 has a membership of about 250 individuals. In more recent years the husband and wife ecologists Drs Evie Merrill and Mark Boyce, have led the way in Alberta on TWS initiatives. In previous years Drs Margo Pybus and Bill Samuel were very active within ACTWS and continue to participate in its varied activities.

Members are associated with a broad spectrum of disciplines associated with universities, government agencies, consultants, various private organizations and industry. Much of the core membership comes from leadership provided by universities and colleges in the province. A very encouraging aspect of ACTWS is its strong and active University of Alberta branch, in which students provide leadership and professional development.

For the website of the ACTWS youth chapter in Edmonton (the University of Alberta entity) visit http://www.ualberta.ca/uatctws/. A similar initiative is in place at the Lethbridge Community College.

Independent from the evolution of CSWFB, CSEB and ACTWS was another professional organization, The Alberta Native Plant Council (ANPC), whose membership consists of botanists and those interested in plant conservation in Alberta. The Alberta Native Plant Council was organized as a result of the 1986 Federation of Alberta Naturalists Workshop on "Endangered Plant Species" in the Prairie Provinces. In 1986, the society was formally established as a registered society. The society meets on a regular annual basis, and in 2010 had a membership of about 200 individuals.

Few could have predicted the outcomes of the struggles that existed in the early 1970s. What is remarkable is the growth and proliferation of both the number of societies and the total population of biologists in the province. From what started as one society with about 12 to 20 members (meeting regularly in private homes in the mid 1960s) to as many as 1500 biologists after 40 years of development. In a larger context there are many more related disciplines with their own professional organizations such as those of foresters, forest technologists, agrologists, limnologists, chemists, fisheries biologists and landscape architects. One estimate places a total of a possible 2500 professional members in Alberta. It is not surprising that a resource rich province, such as Alberta, has been at the forefront in developing biological societies in Canada.

Acknowlegments

We thank Shauna Prokopchuk and Joy Sager of Managewise, the company that does most of the administrative work for the Alberta Society of Professional Biologists, for quickly providing much needed historical information. Joe Nelson and Bill Wishart provided relevant information that was included in this paper. Shannon Pedersen and Art Rodgers, from The Wildlife Society, provided data that were used in updating figures for the current status of this professional society. Thanks are also given to Shirley Bartz, P.Biol., of Winnipeg, and to Lloyd Saul of ERIN Consulting in Regina, and Don Harron, P.Biol., of Calgary, for providing last-minute information for this article.

Received 18 February 2010
Accepted 19 November 2010

APPENDIX A. PUBLICATIONS OF THE CANADIAN SOCIETY OF ENVIRONMENTAL BIOLOGISTS

Updated to October 2010

Publications may be ordered by payment or invoice to: CSEB National Office, P.O. Box 962, Station F, Toronto, Ontario M4Y 2N9 Canada.

Northcote, Tom. *Editor*. 2007. Limnology – The publicly unknown science of inland waters: Overviews on some of its important topics. Canadian Society of Environmental Biologists Newsletter/Bulleting 64(1): 1-50. ($20.00 + $2.50 S&H).

This special publication includes seven papers discussing limnological topics including faecal pollution in inland waters, cumulative effects of climate warming and human demands on freshwater, drinking water treatment, mining development and impacts on aquatic resources in the Canadian North, and forestry and freshwater in Canada.

Canadian Society of Environmental Biologists. 2001. The New Millennium: Can threatened/endangered species recover? Proceedings of the 40th Annual Meeting of the Canadian Society of Environmental Biologists, Vancouver, British Columbia, February 16-17, 2001. 103 pages ($20.00 + $2.50 S&H).

The proceedings include papers and abstracts of presentations on the biology and management of threatened and endangered species, as well as CSEB's comments on the Species at Risk Act that were forwarded to the Parliamentary Committee on Environment.

Ryan, P. M., *Editor.* 1999. Assessment and impacts of megaprojects. Proceedings of the 38th Annual Meeting of the Canadian Society of Environmental Biologists in collaboration with the Newfoundland and Labrador Environment Network, St. John's, Newfoundland. Canada, October 1-3, 1998. Canadian Society of Environmental Biologists. Toronto. x + 233 pages. ($25.00 + $2.50 S&H).

The 1998 CSEB Annual Meeting was designed to constructively review environmental assessment goals, processes, achievements, and failures; particularly as they apply to large-scale projects. Topic areas included assessment processes and their components as well as case studies and critiques. The proceedings consist of 21 invited and contributed papers and participants' formal comments and recommendations pertaining to environmental assessment.

Canadian Society of Environmental Biologists. 1999. Fish and wildlife research and management: applying emerging technologies. Proceedings of the 37th Annual Meeting of the Canadian Society of Environmental Biologists, Edmonton, Alberta, September 28-30, 1997. 136 pages. ($20.00 + $2.50 S&H).

The proceedings include 12 papers and 22 abstracts of presentations on the use of new technology being used in the field of fish and wildlife research and management. Specific sessions dealt with computer modeling and simulation, use of DNA, and isotopes, use of GIS and GPS, habitat improvement techniques, use of telemetry and acoustics, and biomonitoring.

Epp, Henry T. *Editor.* 1997. Ecological reclamation in Canada at century's turn. Proceedings of the 35th Annual Meeting of the Canadian Society of Environmental Biologists, Regina, Saskatchewan, September 26-29, 1995. 123 pages. ($20.00 + $2.50 S&H).

The meeting theme was ecological reclamation or restoration of land and waters in Canada previously disturbed by human activities. Specific papers included restoration of lands disturbed by mining, road building, urban activities, wetland alteration, irrigation, and river alteration. The proceedings also includes a thematic paper by the editor which explains the fit of this series of papers into the overall conference theme.

Delisle, C. E., and **M. A. Bouchard. 1996.** Proceedings of the 19th international symposium on wastewater treatment, 8th workshop on drinking water, and 36th annual meeting of the Canadian Society of Environmental Biologists, Montreal, Quebec. November 19-21, 1996. 449 pages. ($25.00 + $2.50 S&H).

A collection of 50 full presentations or abstracts on quality, quantity, and treatment of urban, industrial, and agricultural wastewater, goundwater, and drinking water. The book deals with research, design, construction, operation, and management of works as well as technological progress in these specialized fields. Predominantly in French.

Dushenko, W. T., H. E. Poll, and **K. Johnston.** *Editors.* 1995. Environmental impact assessment and remediation: towards 2000. Proceedings of the 34th annual meeting of the Canadian Society of Environmental Biologists, Royal Roads Military College, Victoria, British Columbia, June 1-3, 1994. 192 pages. ($30.00 + $2.50 S&H).

A collection of 19 full formal presentations and 14 abstracted poster presentations on environmental criteria, guidelines, legislation, theory, practice, and remediation. The book also contains a 5 page summary of a panel discussion on "Environmental health of the Strait of Georgia/Juan de Fuca Strait – the next Great Lakes?"

Ryan, P. M., *Editor.* 1993. Managing the environmental impact of offshore oil production. Proceedings of the 32nd annual meeting of the Canadian Society of Environmental Biologists, St. John's, Newfoundland, Canada, April 1-4, 1992. 169 pages ($25.00).

This book contains 18 formal papers dealing with policy, monitoring, and wildlife/fisheries resource protection connected with hydrocarbon development in Canadian and international waters.

Yan, N. D. *Editor.* 1991. Natural resources: riches or remnants? Proceedings of the 1991 conference of the Canadian Society of Environmental Biologists, Toronto, April 4-5, 1991. 102 pages. ($20.00 + $2.50 S&H)

This book contains 17 formal papers on the status of soils, lakes, forests and wildlife in Canada. It includes descriptions of current attempts to include natural resource values in national accounts, and of the national environmental indicators program.

Delisle, C. E., and **M. A. Bouchard.** *Editors.* 1990. Joules in the water: Managing the effects of hydroelectric development. A symposium sponsored by the Canadian Society of Environmental Biologists, Montreal, April 6-7, 1989. Collection Environnement et Geologie, Vol. 9, Universite de Montreal. 650 pages. (Out of Stock).

This proceeding includes 32 papers by authors of various scientific backgrounds from across Canada. Papers focus on two mega-projects in Quebec and Manitoba, although specific

impacts of numerous other projects from across the country (Ont., B.C., Sask., Alb., N. S., and Nfld.) are examined. The book considers impacts on natural resources as well as socio-economic impacts of hydroelectric development.

Canadian Society of Environmental Biologists. 1990. Sustainable use of Canada's forests: are we on the right path? A symposium sponsored by the Canadian Society of Environmental Biologists, Kananskis, Alberta, 1990. 158 pages. ($15.00 Xerox reprint + $2.50 S&H)

Eighteen papers and a panel discussion are featured in this book. Eight speakers from 5 provinces look at the use and management of Canada's timber resources in the first section followed by a session which examines the importance of forests for uses and resources other than timber – birds, wildlife, old-growth ecosystems, and tourism.

Canadian Society of Environmental Biologists and the Alberta Society of Professional Biologists. 1988. Seeking consensus: the public's role in environmental decision making. A symposium sponsored by the Alberta Chapter of the Canadian Society of Environmental Biologists and the Alberta Society of Professional Biologists, Edmonton, Alberta, April 26-27, 1988. 115 pages. ($14.00 Xerox reprint + $2.50 S&H)

This conference examined changes that have occurred in the way the public participates in environmental decision making, the effectiveness of communications in raising public awareness, the use of economics to influence public perception, and the role of the public in influencing environmental decisions in Alberta. Fourteen papers are included.

Sanderson, K. *Editor*. 1987. Conservation strategies in Canada. Canadian Society of Environmental Biologists Newsletter 44(2). 108 pages. ($12.00 Xerox reprint + $2.50 S&H)

This book is a special edition of the CSEB Newsletter documenting Canada's attempts to implement the World Conservation Strategies of the International Union for Conservation of Nature and Natural Resources. It contains 15 papers dealing with descriptions of the strategies, and the progress towards implementation by the Canadian Wildlife Federation, the World Wildlife Fund, and the Canadian and Provincial governments.

Powter, C. B. 1987. Reclamation targets for the 1990s. Proceedings of a symposium of the Alberta Society of Professional Biologists, the Canadian Land Reclamation Association, and the Alberta Chapter of the Canadian Society of Environmental Biologists, Edmonton, Alberta, May 4-5, 1987. 118 pages. ($14.00 Xerox reprint + $2.50 S&H).

A collection of 18 papers examining emerging issues in reclamation of industrial sites, wildlife habitat, agricultural soils, and urban landscapes. The book includes the measurement of reclamation success by government, industry, biologists, landscape architects, and the public.

Canadian Society of Environmental Biologists. 1986. Tourism and the environment./Conflict or harmony? A symposium sponsored by the Canadian Society of Environmental Biologists Alberta Chapter, Calgary, Alberta, March 18-19, 1986. 127 pages. ($14.00 Xerox reprint + $2.50 S&H).

This symposium responded to a growing interest in tourism as a major growth industry. The book contains 18 papers dealing with the role of natural resources in attracting tourists, the maintenance of heavily used attractions, and whether or not use and preservation are natural goals.

Canadian Society of Environmental Biologists. 1985. Economy and ecology: the economics of environmental protection. A symposium sponsored by the Canadian Society of Environmental Biologists Alberta Chapter, Edmonton, Alberta, Feb. 19-20, 1985. 224 pages ($18.00 Xerox reprint + $2.50 S&H).

This book contains 18 papers providing a broad perspective integrating the economy and environment. The topic areas include: Assigning values to environmental things; The economics of pollution and pollution control; Environmental and economic factors affecting decision making, and; Public attitudes towards common property resources.

Canadian Society of Environmental Biologists. 1984. Decision making: the role of environmental information. A symposium sponsored by the Canadian Society of Environmental Biologists Alberta Chapter, Red Deer, Alberta, March 17, 1984. 126 pages ($12.00 Xerox reprint + $2.50 S&H).

A collection of nine papers covering: the decision process; case histories and experiences; the public and decision making, and; the role of science in government policy and decision making.

Canadian Society of Environmental Biologists. 1983. Resource management in the eastern slopes. A symposium sponsored by the Canadian Society of Environmental Biologists Alberta Chapter, Red Deer, Alberta, March 19, 1983. 98 pages ($12.00 Xerox reprint + $2.50 S&H).

The views of a cross-section of resource users are presented. Featured are an analysis of government policy and planning for Alberta's eastern slopes and a panel discussion on resource interactions and conflicts.

Canadian Society of Environmental Biologists. 1982. Agriculture and the environment. A symposium sponsored by the Canadian Society of Environmental Biologists Alberta Chapter, Red Deer, Alberta, March 6, 1982. 139 pages ($14.00 Xerox reprint + $2.50 S&H).

A collection of 12 papers addressing the major issues related to agriculture and the environment including land use conflicts, effects of industrial activities and the impacts of agricultural activities on land and water.

APPENDIX B – ASPB (Alberta Society of Professional Biologists) publications

Contact ASPB at www.aspb.ab.ca, or phone 780-434-5765 for price and mailing costs.

2007. Solutions to Ecological Issues in the Oil Sands (in preparation, but will be CD only). *Editor:* Laurie Hamilton, P.Biol.

2006. Water: Science and Politics. (CD and Hard Copy). *Editors:* Henry Epp, P.Biol., and Dave Ealey, P.Biol. 282 pages.

2004. Prediction to Practice: Environmental Assessment Follow-up. (CD and Hard Copy). *Editors:* Henry Epp, P.Biol., and M. Kerry Brewin, P.Biol. 173 pages.

2003. Access Management: Policy to Practice. (Hard Copy only). *Editor:* Henry Epp, P.Biol. 239 pages.

2000. Cumulative Environmental Effects Management – Tools and Approaches. (Hard Copy only). *Editor:* Alan J. Kennedy, P.Biol. 487 pages.

1994. Cumulative Effects Assessment in Canada – From Concept to Practice. (Hard Copy only). *Editor:* Alan J. Kennedy, P.Biol. 333 pages.

1986. Native People and Renewable Resource Management. Judith Smith, P.Biol., and Jeffrey Green, P.Biol. 275 pages.

Donald Evan McAllister, 1934-2001: The Growth of Ichthyological Research at the National Museum of Canada/Canadian Museum of Nature

Francis R. Cook, Brian W. Coad, Claude B. Renaud, Charles G. Gruchy, and Noel R. Alfonso

Canadian Museum of Nature, P.O. Box 3443, Station D, Ottawa, Ontario K1P 6P4

Cook, Francis R., Brian W. Coad, Claude B. Renaud, Charles G. Gruchy, and Noel R. Alfonso. 2010. Donald Evan McAllister, 1934-2001: the growth of ichthyological research at the National Museum of Canada/Canadian Museum of Nature. Canadian Field-Naturalist 124(4): 330–335.

Don McAllister was curator of fishes, researcher, and biodiversity specialist from 1958 to 2001 for the National Museum of Canada ("rebranded" as the Canadian Museum of Nature in 1990). His contributions were recognized by The Ottawa Field-Naturalists' Club which made him an Honorary Member in 1986 (Brunton et al. 1987). Don was born 23 August 1934 in Victoria, British Columbia. He married fellow University of British Columbia student Nancy Ann Mahoney in the 1950s and together they raised five children: Fern, Wendy, Sylvia, Jean, and Bruce. Nancy died in 1983. Don remarried, in 1992, to Lise Janssen who had been a volunteer in the herpetological section of the museum 1985-1991. He died in hospital in Toronto, Ontario, 17 June 2001, while waiting for a transplant to replace his liver, damaged from effects of hepatitis C contracted from blood transfusions received during colon surgery 20 years before. It is sadly ironic that Don would succumb to the effects of tainted blood as he had been a monthly blood donor over many years.

Don arrived at the National Museum of Canada 1 August 1958 having established himself as a researcher in the making. He had obtained his Master's thesis on sculpins at the University of British Columbia under the supervision of legendary ichthyologist Casimir C. Lindsey. He followed this with a year as a National Science and Engineering Research visiting student at the Museum of Zoology, University of Michigan. At both institutions he obtained a basic grounding in curating fish collections.

Although the museum had specialists in other vertebrate groups (birds, mammals, and amphibians and reptiles) for over 50 years, there had never been an ichthyologist on the permanent staff of Canada's federal natural history museum (variously named the Museum of the Geological Survey of Canada 1843, of the Geological and Natural History Survey of Canada 1877, the Victoria Memorial Museum 1910, the National Museum of Canada 1927, the National Museum of Canada, Natural History Branch 1957, the National Museums of Canada, National Museum of Natural Sciences 1967). The Survey, from its inception, had accumulated collections, first in geology, and soon after in natural history, both for display and research (Collins 1927; Russell 1961; Zaslow 1975; Cranmer-Byng 1996).

Fishes had been regarded on the federal scene as largely the responsibility of a fisheries department (variously included in the Department of Naval Service, Marine and Fisheries, Dominion Department of Fisheries, Department of Fisheries and Oceans). However, many of the early Survey staff (e.g., geologists R. Bell, G. M. Dawson, A. P. Low, palaeontologist-zoologist and museum curator, J. F. Whiteaves, and botanist-naturalist John Macoun, assisted by James M. Macoun, W. Spreadborough and C. H. Young), did include fishes in their sampling. John Macoun published a list of western fishes (Macoun 1882) but surviving museum specimens begin with a collection made 16 August 1883 by John Macoun from Anticosti Island. Whiteaves (1886) included fishes in a list of Canadian Atlantic marine vertebrates and invertebrates. Bean and Weed (1920) published on specimens obtained by Young and Spreadborough on Vancouver Island in 1909.

At least from 1885 the Department of Naval Service maintained its own museum in Ottawa, the Canadian Fisheries Museum. It was overseen by Associate Zoologist, Naturalist, and Curator Andrew Halkett (Lloyd 1939). Halkett produced the *Checklist of the Fishes of the Dominion of Canada and Newfoundland* (1913) and retired after 52 years of government service at the age of 75 in 1929. The Fisheries Museum, however, was closed when its building was to be demolished, and in March 1918, its specimens of mammals, birds (including eggs), reptiles and amphibians, crustaceans, and coelenterates were transferred to the Victoria Memorial Museum along with 42 collections of fish which were re-catalogued there.

Early fish collections, that later formed part of the slender initial base for Don's studies nearly a half century later, were made in the Canadian Arctic by Danish biologist Frits Johansen (Porsild and Bousfield 1959). Johansen was a member of a joint Geological Survey and Department of Naval Service sponsored Canadian Arctic Expedition as entomologist, marine biologist and botanist. He was on the staff of the Geological

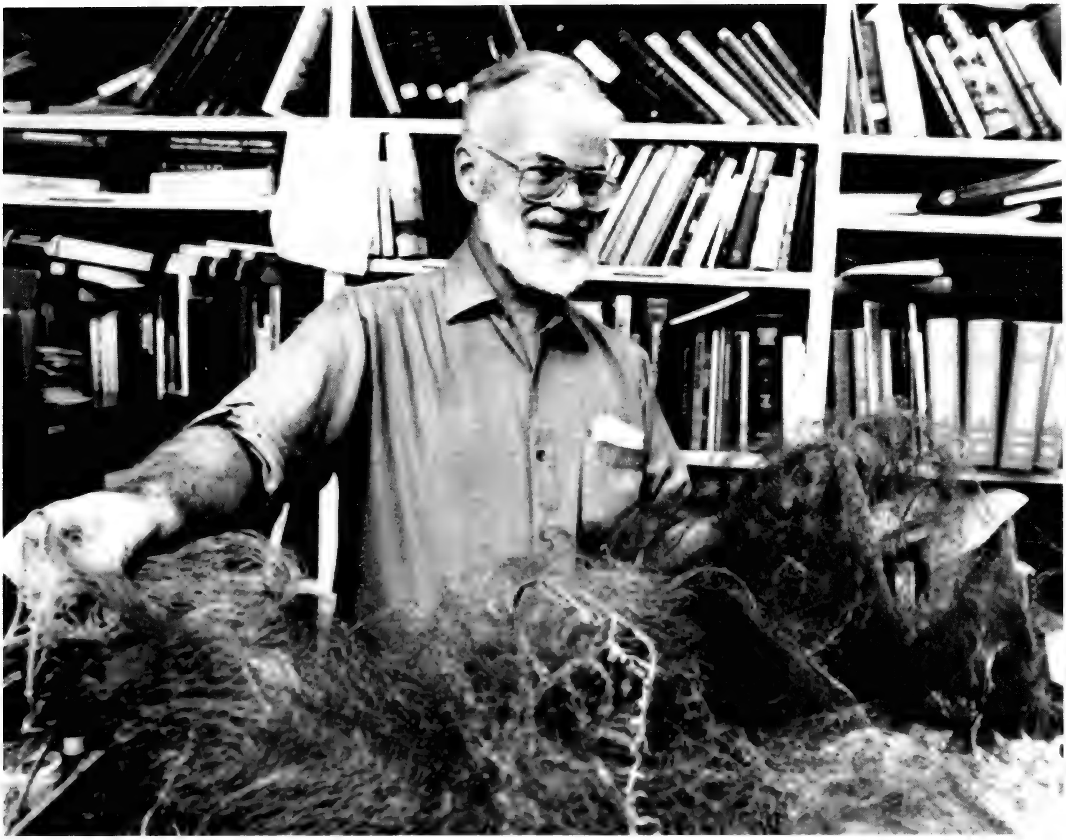


FIGURE 1. Don at his desk in the "Beamish Building" (1501 Carling Avenue) displaying a fine mesh net for use by Phillipine fishermen to capture coral reef fish for the aquarium trade. Use of these nets was promoted to replace cyanide and thus dramatically reduce mortality of both fish and associated marine life. *Ottawa Citizen* 27 November 1986, reproduced by permission.

Survey during 1916 to 1918 and his Arctic collections were deposited in the Victoria Memorial Museum. Johansen partially completed a manuscript on the fishes collected and observed, intended for Volume 6, Part A, of *Report of the Canadian Arctic Expedition 1913-18*, but it never appeared. A draft was apparently completed in 1926 or 1927 but not submitted to the museum until 1934 (an incomplete copy is in the museum archives). Eventually, it was used by and American ichthyologist (Walters 1953). However, Johansen's botanical contribution (which was the first comprehensive description of the vegetation of the western North American Arctic) was published in one of two botanical volumes based on his collections. He also contributed three faunistic reports as part of the seven volumes of invertebrate papers by various authorities based on his specimens.

Successive herpetologists (C. L. Patch 1913 to 1950; J. S. Bleakney 1952 to 1958) at the National Museum were nominally in charge of curating the fish collections but produced only one ichthyological paper (Bleakney 1954). Only about 500 specimens were catalogued, all in the period 1914 to 1926, and 4000 additional uncatalogued specimens were added, half between 1926 and 1951, and half after during Bleakney's tenure.

Both federal and provincial fisheries research were primarily focused on managing commercial and sport species, leaving unfulfilled the need for a systematic ichthyologist at the federal level who could cover both marine and freshwater non-commercial species. This role had gone by default largely to the Royal Ontario Museum in Toronto (associated with the University of Toronto), and the British Columbia Provincial Museum (later renamed the Royal British Columbia Museum) in Victoria and the University of British Columbia with later contributions from the Nova Scotia Museum, New Brunswick Museum, University of Manitoba, and University of Alberta, all maintaining research collections. The University of Toronto ichthyologist, Professor J. R. Dymond, was also director of the Royal Ontario Museum of Zoology (Dymond 1940, 1964) but the first formal Curator of Fishes position at a Canadian museum was not created until 1948 when W. B. Scott

was appointed. E. J. Crossman was added as Assistant Curator in 1955 (Dymond 1964). Later this pair produced the definitive volume on Canadian freshwater fish (Scott and Crossman 1973).

Soon after arrival in Ottawa, Don launched into research on the marine fish of Arctic Canada, the missing piece in comprehensive coverage of Canadian fishes, as books on the Pacific, the Atlantic, and the freshwater species had appeared or were planned, sponsored by Fisheries and Oceans. In 1960, Don produced a preliminary checklist followed by keys, and a series of research papers on individual groups or species soon followed. In 1975, he completed a more comprehensive list of scientific, English, French, and Inuktituk names of Arctic fishes in collaboration with V. Legendre and J. G. Hunter, revised in 1987; in 1984, a distributional atlas of Arctic records in the National Museum with Hunter, Shirley Leach, and Michèle Steigerwald; and in 1986, a bibliography of marine fishes of Arctic Canada 1771-1985 with Steigerwald. He compiled extensive files and a database on which his successors continued to build. Peripheral interests repeatedly distracted Don from finishing it himself. In the fall of 1960, he took educational leave to complete residency requirements for a Ph.D. at the University of British Columbia. His thesis *Evolution of branchiostegal rays in teleostome fishes,* supervised by J. C. Briggs and R. H. Rosenblatt, was accepted in 1964 and published by the museum as Bulletin 221 in 1968. (Nancy's Ph.D. thesis, on grebe behaviour, done simultaneously at the University of British Columbia, was accepted before Don's). He also published on such varied topics as the evolution of the black peritoneum in fishes (1960), a revision of the smelt family (1963), numerical taxonomy of smelts (1966), and the significance of ventral bioluminescence in fish (1967). His enthusiasm for Pleistocene fossil fish led to papers on Green Creek remains from the Champlain Sea in the Ottawa District, on fossils from the Yukon, and on more recent remains from various archaeological sites in Canada. A star acquisition obtained by museum purchase was a specimen of the "living fossil" from off Madagascar in 1969, the Coelacanth, *Latimeria chalumnae.* In 1971, he published a detailed review of the species and the information contributed by the new specimen. Also in 1971, with E. J. Crossman of the Royal Ontario Museum, Don wrote *A guide to the freshwater sport fishes of Canada.* In 1974, Don's extensive local collecting led to *The Fishes of Canada's National Capital Region/ Poissons de la region de la Capital du Canada* co-authored with Brian Coad. In 1980, Don was a co-editor and co-author of the *Atlas of North American Freshwater Fishes* published by the North Carolina State Museum. In 1986 he again collaborated with Crossman, this time on the zoogeography of freshwater fishes of the Hudson Bay drainage, Ungava Bay and the Arctic Archipelago, as a chapter in *Zoogeography of North American Freshwater Fishes.*

FIGURE 2. Don and Pat Bleeks in the fish laboratory at the Beamish Building, Ottawa, examining the newly arrived Coelacanth, August 1969

Don was an innovator in museum procedures, publishing a chapter on methods of collecting and preserving fishes in 1965, and using x-rays for taxonomic studies in numerous papers. He was a pioneer and advocate for the computerization of museum collections and devised a detailed field data input sheet for standardizing information recorded with specimens. *The compleat minicomputer cataloguing and research system for a museum* was co-authored with R. Murphy and J. Morrison in 1978. Don also compiled a comprehensive list of terms and definitions (since expanded by BWC and available at www.briancoad.com). Another project was a file and reprint library of ichthyological papers from around the world with particular emphasis on Canada and especially on the Arctic. Don organized the 1974 Annual Meeting of the American Society of Ichthyologists and Herpetologists in Ottawa, only the third time the society had met in Canada and the first to be bilingual. Don was an active member of the Fish and Marine Mammals Subcommittee of COSEWIC (Committee on the Status of Endangered Wildlife in Canada) and wrote the first endangered fish list for Canada (1970). A complete bibliography, compiled by BWC follows this tribute.

As curator and researcher of the ichthyology section, Don attracted, trained and had a lasting influence on a multitude of excellent staff, several of whom went on to fill other important roles at the museum and elsewhere. Assistant Curators started with CGG (first

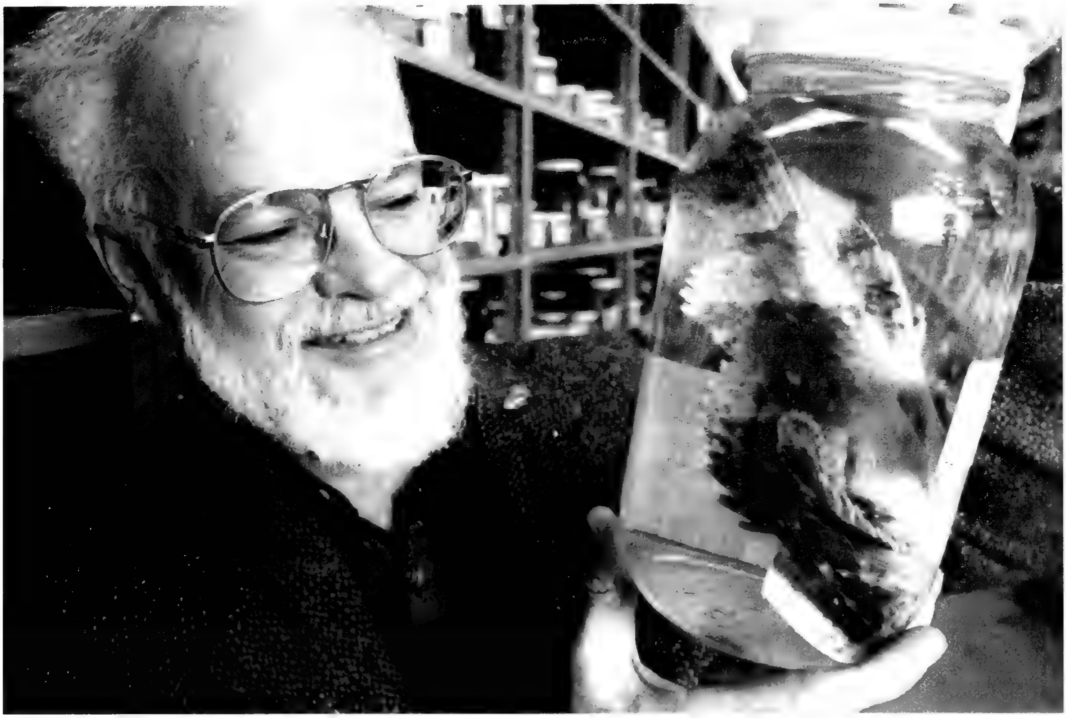


FIGURE 3. Don and a specimen of the Spotted Scorpionfish, *Scorpaena plumieri*, (family scorpaenidae) CMNF: (Canadian Museum of Nature, Fish) 1976-0173 Florida, Munroe County, 24°33'30"N, 81°43'30"W). A portion of the Canadian Museum fish collection is in the background. *Ottawa Citizen* 5 May 1991, reproduced with permisssion.

hired on a cataloguing contract 1 April 1969 and made permanent 25 May 1970). In January 1977 he left ichthyology to become acting chief, then chief, of the Invertebrate Zoology Division. He later moved up to Assistant Director of the Museum in 1981, Acting Director in 1982, and back to Assistant Director in 1983. (Subsequently, he become Director General of the Canadian Conservation Institute). BWC obtained his Ph.D. at the University of Ottawa in 1976, taught at the University of Shiraz, Iran, undertook comprehensive studies of the Iranian ichthyofauna, and returned to Canada in 1979. He was a Research Associate with the Museum 1979 to 1981 while he catalogued his large Iranian collection and was appointed Associate Curator of Fishes 18 March 1981, and Curator in 1986.

The first fish technician (Curatorial Assistant) at the National Museum, Stan Gorham, was shared with herpetology in 1964 to 1965. Stan had been a general zoology technician at the museum from 1953 to 1964; and subsequently was solely herpetology technician in 1965 before going on to the New Brunswick Museum that year to become curator of zoology). His replacement from 1966 to 1968, Bill Van Vliet, left the museum for graduate work and drowned during field research while diving in Lac Heney in the Gatineau region of Quebec. From 1968 to1970, Tom Willock was Curatorial Assistant. He later became Director of the Medicine Hat Museum in Alberta. Jadwiga Aniskowicz (now Frank) was hired on contract in 1970 and was curatorial assistant 1973 to 1993. Michèle Bélanger (now Steigerwald) was hired on contract in 1978 and Sylvie Laframboise in 1982. Both later attained permanent status and have remained with the museum in the new Collections Division created in the 1991 re-organization. Numerous contractees, summer students, and workers from government employment projects have also passed through the ichthyology section, numbering over one hundred people.

Post-doctoral students in ichthyology were Alex Peden 1970 (who became a curator at the British Columbia Provincial Museum), Rick Winterbottom 1972-1973 (who went to South Africa and returned for 1977-1978, before taking a research position at the Royal Ontario Museum) and Labbish Chao 1976 (who went on to research in Brazil). Research Associates were Vadim D. Vladykov, Professor and later Emeritus Professor of Biology, University of Ottawa, from 1973 to 1986, and Garry M. Bernacsek in 1983. Douglas Copeman was Visiting Scientist on sabbatical from the Memorial University of Newfoundland 1976-1977. Don was thesis co-supervisor (with Professor Sami Qadri) for CBR at the University of Ottawa. Claude

joined the museum staff as Assistant Curator, 24 November 1986, to BWC replaced associate curator when the latter became curator. François Chapleau was a postdoctoral fellow in 1987 and was appointed to the staff of the University of Ottawa in 1988.

During the 28 years Don was Curator of Fishes, the collection ballooned from 4638 specimens (virtually all from Canada and majority of them uncatalogued) to about 410 000 catalogued specimens from Canada alone, as well as an ever-increasing collections worldwide. This was the result of staff expeditions, contracts, donations, purchases, and exchanges with other institutions. Subsequent to his handing on the curator post to BWC, the collection continued to grow, and by 1991 when a separate collection division was formed, totalled 581 949 specimens world-wide, with 450 276 of these Canadian. Recent totals are 676 597 specimens with 504 910 Canadian. Included in the totals are 42 holotypes, 4 neotypes, 2288 paratypes, 41 syntypes, and 67 topotypes (Sylvie Laframboise, personal communication 18 January 2011).

The database for this collection, first computerized under Don's direction, plus his extensive file of literature, was the basis for Don's preparation of a list of families and species of fish of the world covering some 20 000 taxa. Eventually the project was superseded by the *Catalog of Fishes* originated by Bill Eschmeyer in California which had vastly greater resources (supplied by the United States National Science Foundation), whereas Don had worked from a limited Canadian museum budget and some meagre additional contributed funds.

While serving in his broad and varied role as a museum curator and researcher, Don also held adjunct professorships at both University of Ottawa, beginning in 1969 (where he taught courses in ichthyology), and Carleton University (also in Ottawa) beginning in 1980. He participated on graduate student committees at both. Van Vliet, CGG, BWC, and CBR did graduate work at Ottawa University, Willock at Carleton. Among the various organizations in which he participated, perhaps one of the most important in Canada was the Fish and Marine Mammals Subcommittee of COSEWIC (Committee on the Status of Endangered Wildlife in Canada) which, on the basis of detailed status reports, made designations of species at risk in Canada.

After a position shift to senior researcher in 1986, Don increasingly applied his experience and social conscience to broader concerns for the planet through writing, editing, and international committees; leading eventually to his moving into the museum's newly created biodiversity group in the 1990s. He was increasingly active through efforts in lobbying, and through serving on such committees as the IUCN SSC Coral Reef Specialist Group as co-chair. He was twice a member of the Canadian delegation on the negotiations for the Convention on Biological Diversity and was a member of the Canadian delegation to scientific and technical advisory body for the Biodiversity Convention and a participant in the Global Biodiversity Forum. Earlier, he had founded and edited the quarterly *Sea Wind*. In 1991, he originated and edited the quarterly *Canadian Biodiversity* (later *Global Biodiversity*) published by the Canadian Museum of Nature, which totalled 8 volumes but discontinued in 1999. It was replaced the next year by *Biodiversity: A Journal of Life on Earth* with the Tropical Conservancy as publisher, and Don as Editor. He volunteered to take early retirement from the museum in 1993, in a characteristic selfless gesture meant to free a position to enable younger staff to be retained in a period of museum downsizing, but continued his close ties as Researcher Emeritus and Research Associate. He mortgaged his home to fund his effort to promote sustainability in collection of aquarium fish by Phillipine fishermen.

Don left an indelible mark on the museum in many other ways, helping to popularize sports shirts to replace the traditional white ones and ties, pioneering Christmas staff plays which freely lampooned staff and policies, and promoting collegial staff coffee breaks. He also became a leading advocate for bilingualism and computerization at the museum by his example. His work habits included a free-range filing system where multiple piles of correspondence, manuscripts, books, and specimens from his simultaneous projects spread to cover every available surface in his office, but from which he rarely failed to find any item requested. This made it a featured stop on visitors' tours of the museum temporary research facilities at Carling Avenue from 1967 to 1991. Ultimately, it was included as a fire hazard among over 90 Labour Canada code violation citations. These helped speed a move to a new collection and research facility, this one on a site across the Ottawa River in Aylmer [now Gatineau], Quebec.

Of the two journals Don founded, Sea *Wind* and its publisher, initially Ocean Voice then as The International Marine Alliance, which Don also was a founder, have ceased. They focused attention to marine conservation, including promoting replacement of the non-sustainable fishing practices using cyanide for collecting tropical aquarium species with use of nets to reduce collection mortalities and environmental damage. The broader *Biodiversity* has survived under a succession of editors including distinguished biologists Ted Mosquin and Geoff Scudder.

The Don E. McAllister Memorial Scholarship has been created at the University of Ottawa, sponsored through the winding up of *Sea Wind* accounts and donations, to provide financial assistance to graduate students working on the taxonomy/systematics of fishes, or on biodiversity/conservation issues. Application must be made to the Director of Financial Aid and Awards Service (www.uOttawa.ca/loansandawards). Applicants must (1) be registered as a full time graduate student in the Faculty of Science, Department of

Biology at the University of Ottawa, (2) be an Ontario resident, as per OSAP (Ontario Student Assistance Program) rules, (3) demonstrate financial need, as determined by the Financial Aid and Awards Service of the University of Ottawa, (4) be studying in the area of taxonomy/systematics of fishes or on biodiversity/ conservation issues.

The McAllister legacy and its influence at the Canadian Museum of Nature is evident though continuing staff that he first recruited, BWC and CBR as research scientists and NA as research assistant in the Research Services Division, and Sylvie Laframboise (fish) and Michèle Steigerwald (amphibians and reptiles) assistant collection managers in the Collections Services Division. A primary McAllister research initiative will finally be realized this year by completion of the manuscript for *Arctic Marine Fishes of Canada*, dedicated to him and edited by Brian W. Coad and James D. Reist, with contributions by Noel Alfonso, Fikret Berkes, Peter Rask Møller and Claude B. Renaud. With the financial assistance of Fisheries and Oceans Canada, this completes the missing piece of the comprehensive references to Canada's fish fauna so vitally important as benchmarks for planning future research priorities. Its completion is timely in this era of increasing concern about global warming and Canadian Arctic sovereignty.

Acknowledgments

The text of this tribute has drawn extensively on previous tributes to Don mostly by, or based on information contributed in part, by the present authors. Sylvie Laframboise supplied the totals for the fish collection at various periods.

Cook, F. R. 2001. Donald Evan McAllister: Eulogy: delivered by F. R. Cook at Christ Church Cathedral, Ottawa, 30 June 2001

Cook, F. R., and **B. W. Coad.** 2001. Donald Evan McAllister: Curatorial and research contributions at the Canadian Museum of Nature. Sea Wind 15(1/2): 46-53.

Cook, F. R., B. W. Coad, and **C. B. Renaud.** 2002. Donald Evan McAllister 1934-2001. Copeia 2002(3): 890-894.

Cook, F. R., C. G. Gruchy, and **B. W. Coad.** 2001. Donald Evan McAllister, 1934-2001: A tribute. Amphipacifica: Journal of Aquatic Systematic Biology 3(2): 1-2.

Dang, P. T. 2001. A tribute to Don E. McAllister. Biodiversity 2(3): 22-23.

Mosquin, T. 2002. Some reflections on the life and work of Don E. McAllister. Biodiversity 3(1): 7-10. [with inset comments by Anne Breau, Richard Laing, Alan Emery, Francis R. Cook, and Fred Schueler].

FRC, as Curator of Amphibians and Reptiles (herpetology), spent most of 30 years (1960-1991) in an adjoining office, or in one separated from Don only by the assistant curator's office (in the Victoria Memorial Museum Building from 1960 to 1967 and later at the "Beamish" warehouse building on 1501 Carling Avenue), until Don moved to Biodiversity offices. As well as daily contact throughout most of their museum careers, there were frequent joint local collecting expeditions, and often social occasions beyond the museum duties. All of us are indebted to him for unfailing comradeship and encouragement of our individual views and projects throughout, and often as well for his statistical and computer knowledge and numerous other bits of advice, taken or not. NA originally requested FRC to write a tribute to celebrate Don's contributions for *Sea Wind* while he was alive. BWC and CBR contributed detail on the ichthyology collection growth, staff and publications and discussions of Don's contribution from their particular perspectives and extensively contributed to this and previous accounts cited. CGG and NA added recollections of their long association and joint projects with Don.

Literature Cited

Bean, T. H., and **A. C. Weed.** 1920. Notes on a collection of fishes from Vancouver Island, British Columbia. Proceedings and Transactions of Royal Society of Canada (1919) Series 3, 13: 69-83, 4 plates.

Bleakney, S. 1954. Food habits of lake trout from Squaw Lake, northern Quebec. Canadian Field-Naturalist 68(2): 94.

Brunton, D., and **the members of the Ottawa Field-Naturalists' Club Awards Committee.** 1987. New Honorary Members and the 1986 Ottawa Field-Naturalists' Club Awards: Honorary Member Donald E. McAllister. Canadian Field-Naturalist 101(4): 617.

Collins, W. H. 1927. The National Museum of Canada. Geological Survey of Canada, Museum Bulletin 50.

Cranmer-Byng, J. L. 1996. A life with birds: A biography of Percy Algernon Taverner, 1875-1947. Canadian Field-Naturalist 110(1): 1-254.

Dymond, J. R. 1940. History of the Royal Ontario Museum of Zoology. Royal Ontario Contributions 18.

Dymond, J. R. 1964. A history of ichthyology in Canada. Copeia 1964(1): 2-33.

Lloyd, H. 1939. Andrew Halkett Naturalist 1854-1937. Canadian Field-Naturalist 53(3): 31-32.

Macoun, J. 1882. Notes on reptiles, fishes, and insects. Pages 374-398, with a Catalogue of western fishes. Pages 377-392 *in* Manitoba and the great North-west. World Publishing Company, Guelph, Ontario. 687 pages.

Porsild, A. E., and **E. L. Bousfield.** 1959. Frits Johansen 1882-1957. Canadian Field-Naturalist 73(2): 82.

Russell, L. S. 1961. The National Museum of Canada 1910-1960. Department of Northern Affairs and National Resources, Ottawa. 37 pages.

Scott, W. B., and **E. J. Crossman.** 1973. The freshwater fishes of Canada. Fisheries Research Board of Canada Bulletin 184, Ottawa.

Walters, V. 1953.The fishes collected by the Canadian Arctic Expedition, 1913-18, with additional notes on the ichthyofauna of western Arctic Canada. Bulletin National Museum of Canada (128): 257-274, 1 figure.

Whiteaves, J. F. 1886. Catalogue of Canadian Pinnipedia, Cetacea, fishes, and marine invertebrates. Department of Fisheries. Ottawa.

Zaslow, M. 1975. Reading the rocks: The story of the Geological Survey of Canada 1842-1972, The Macmillan Company of Canada Limited, Toronto, Ontario.

Bibliography of Donald Evan McAllister

Brian W. Coad
Canadian Museum of Nature, Box 3443 Postal Station D, Ottawa, Ontario K1P 6P4

Coad, Brian W. 2010. Bibliography of Donald Evan McAllister. Canadian Field-Naturalist 124(4): 336–358.

Don McAllister wrote a wide variety of articles and books for scientific and popular outlets. He also served as the founder and editor of two journals, *Sea Wind* and *Canadian Biodiversity* (later named *Global Biodiversity* in 1993 and *Biodiversity (Journal of Life on Earth)* in 2000). This work attempts to be a bibliography but does not include numerous unpublished manuscript reports that Don submitted to the Canadian Museum of Nature, Ottawa and to other agencies.

Don published over 625 scientific papers, books, popular articles and book reviews in his career of 45 years from 1957 to 2002. He averaged about 14 publications a year with book reviews numbering about 200 of the items listed here. His work ranged from such topics as systematic revisions of taxa to how to run a "green" school. The first 30 years of Don's publishing career was principally devoted to fishes, their systematics, ecology and conservation. The last 15 years were devoted mostly to biodiversity and conservation of natural resources through the founding of journals and his editorships of them and through lobbying efforts.

His ichthyological works were published primarily in English with some in French, mostly as translations of works originally in English. He shared authorship with over 110 separate collaborators but was first author on 90% of these papers.

The journals for which Don was the editor are listed for each issue. Minor notes, news items both short and long, press releases, annual reports, extracts of articles, quotations, notices of meetings and new books, indices, some short book reviews mostly listing contents of the book, editorial comments, comments on articles and some one page descriptions of species, were probably all authored by Don within these periodicals. These are not listed separately for space reasons but covered by the "Editor and partial author" statement (and it is not always clear that Don authored these unattributed notes, although generally he did). Significant articles and longer book reviews within these edited periodicals clearly authored by Don are listed separately – however the choice of these is necessarily selective and eclectic. The periodicals have numerous unnumbered figures as decoration and as watermarks as well as some that are part of articles, and some are repeated several times as decorative items. These are covered by the statement "numerous text figures" in the general listing by volume and issue.

A few articles are also available on the internet and were only seen in that format, or appear only there. Their URLs were all found in July 2001 and October 2003.

Dates in parentheses after volume number indicate the year of publication as marked on the paper but other evidence suggests the year after the author(s) is the correct one. Some articles, books and journals appeared in both English and French: these are not listed separately.

= not seen in original, or missing information.

McAllister, D. E. 1957. The systematics of the freshwater sculpins of British Columbia. M.A.thesis, Department of Zoology, University of British Columbia, Vancouver. 109 pages. 11 figures, 30 tables.

McAllister, Don E. 1959. Records of marine fishes from fresh water in British Columbia. Canadian Field-Naturalist 73(1): 13-14.

McAllister, D. E. 1959. Review of: The Freshwater Fishes of Canada *by* E. P. Slastenenko. Canadian Field-Naturalist 73(3): 181-182.

McAllister, D. E. 1960. Review of: The Angler's Book of Canadian Fishes by F. H. Wooding. Canadian Geographical Journal 60(1): V.

McAllister, D. E., and **Sherman Bleakney.** 1960. Some freshwater fishes from northeastern Quebec and Labrador. National Museum of Canada Bulletin 166, Contributions to Zoology 1958, Biological Series 61: 31-39, 1 figure, 5 tables.

McAllister, D. E. 1960. Review of: The Fresh-Water Fishes of British Columbia *by* G. Clifford Carl, W. A. Clemens, and C. C. Lindsey. Canadian Field-Naturalist 74(1): 55-56.

#**McAllister, Don E.** 1960. Preliminary translation of keys of: [Observations on the eel-like lycodids [*Lycenchelys* Gill (Pisces; Zoarcidae) and related forms] in the seas of U.S.S.R. and neighbouring waters. Trudy Zoologicheskova Instituta Akademii Nauk SSSR 18: 349-384 by A. P. Andriashev 1955. Fisheries Research Board of Canada Translation Series 278: 1-4.

McAllister, D. E. 1960. List of the marine fishes of Canada. National Museum of Canada Bulletin 168, Biological Series, 62: iv + 76 pages, 1 table. 19 March.

McAllister, D. E. 1960. Keys to the marine fishes of Arctic Canada. Natural History Papers, National Museum of Canada 5: 1-21, 27 figures.

McAllister, D. E. 1960. Le *Gasterosteus wheatlandi*, nouvelle espèce de poisson pour la province de Québec. Le Naturaliste canadien 87(5): 117-118.

McAllister, D. E. 1960. A simple clamp to aid in counting fin rays. Copeia 1960(3): 250, 1 figure.

McAllister, Don E. 1960. Sand-hiding behavior in young white hake. Canadian Field-Naturalist 74(4): 177, 1 figure.

McAllister, Don E. 1960. The twospine stickleback *Gasterosteus wheatlandi* new to the Canadian fresh-water fish fauna. Canadian Field-Naturalist 74(4): 177-178.

#**McAllister, Don E.** 1961. Survey of Cottidae in Japan. A review of M. Watanabe: Cottidae (Pisces), Fauna Japonica. Progressive Fish-Culturist 23(1): 25.

McAllister, D. E. 1961. Review of: Fauna Japonica: Cottidae (Pisces) *by* Masao Watanabe. Canadian Field-Naturalist 75(1): 50.

McAllister, Don E. 1961. Fishes. Pages 131-135 *in* Methods of Collecting and Preserving Vertebrate Animals *by* R. M. National Museum of Canada Bulletin 69, Biological Series 18: 164 pages.

McAllister, D. E. 1961. Northward range extension of the flathead chub and trout-perch to Aklavik, N.W.T. Journal of the Fisheries Research Board of Canada 18(1): 141. 30 March

McAllister, D. E. 1961. Fish remains from a 600-year-old St. Lawrence River Iroquois site. National Museum of Canada Bulletin 172, Contributions to Zoology 1959, Biological Series 65: 34-38, 2 figures. 19 April

McAllister, D. E. 1961. A collection of oceanic fishes from off British Columbia with a discussion of the evolution of black peritoneum. National Museum of Canada Bulletin 172, Contributions to Zoology 1959, Biological Series 65: 39-43.

McAllister, D. E. 1961. The origin and status of the deepwater sculpin, *Myoxocephalus thompsonii*, a Nearctic glacial relict. National Museum of Canada Bulletin 172, Contributions to Zoology 1959, Biological Series 65: 44-65, 3 figures, 6 tables.

McAllister, D. E., and **C. C. Lindsey.** 1961. Systematics of the freshwater sculpins (*Cottus*) of British Columbia. National Museum of Canada Bulletin 172, Contributions to Zoology 1959, Biological Series 65: 66-89, 5 figures, 10 tables.

McAllister, D. E., and **R. J. Krejsa.** 1961. Placement of the prowfishes, Zaproridae, in the superfamily Stichaeoidae. Natural History Papers, National Museum of Canada 11: 1-4. 24 July

McAllister, D. E. 1962. Fish remains from Ontario Indian sites 700 to 2500 years old. Natural History Papers, National Museum of Canada, 17: 1-6, 1 figure, 1 table. 27 August.

McAllister, D. E. 1962. Review of: Fishes of the Pacific Coast of Canada *by* W. A. Clemens and G. V. Wilby. Canadian Field-Naturalist 76(2): 117-118.

McAllister, Don E. 1962. The brassy minnow, river shiner and sauger new to Alberta. Canadian Field-Naturalist 76(2): 124-125.

McAllister, D. E. 1962. Fishes of the 1960 "Salvelinus" Program from western Arctic Canada. National Museum of Canada Bulletin 185, Contributions to Zoology 1962, Biological Series 69: 17-39, 4 figures.

Bousfield, E. L., and **D. E. McAllister.** 1962. Station list of the National Museum marine biological expedition to southeastern Alaska and Prince William Sound. National Museum of Canada Bulletin 183, Contributions to Zoology 1960-61, Biological Series 68: 76-103, 2 figures, 5 maps.

McAllister, D. E. 1963. Review of: The lake sturgeon, a history of its fishery and problems of conservation by W. J. K. Harkness and J. R. Dymond. Canadian Field-Naturalist 76(3) [1962]: 171.

McAllister, D. E. 1963. Review of: Silent Spring *by* Rachel Carson. Canadian Field-Naturalist 76(4) [1962]: 220-221.

McAllister, D. E. 1963. A revision of the smelt family, Osmeridae. National Museum of Canada Bulletin 191, Biological Series 71: iv + 53 pages, 14 figures, 2 tables.

McAllister, D. E. 1963. Systematic notes on the sculpin genera *Artediellus*, *Icelus*, and *Triglops* on Arctic and Atlantic coasts of Canada. National Museum of Canada Bulletin 185, Contributions to Zoology Paper 4: 50-59, 8 figures, 3 tables. March

McAllister, Don E. 1963. The evolution of branchiostegals in teleostome fishes. American Society of Ichthyologists and Herpetologists, 50th Anniversary Meeting, Vancouver, British Columbia June 1963, page 46.

McAllister, D. E. 1963. Review of: Ichthyology *by* Karl F. Lagler, John E. Bardach and Robert R. Miller. Canadian Field-Naturalist 77(3): 171.

McAllister, D. E. 1963. Review of: Fishes of Ontario *by* H. H. MacKay. Canadian Field-Naturalist 77(4): 230.

McAllister, D. E. 1963. Fish remains from a 600-year-old Yukon archaeological site. Canadian Field-Naturalist 77(4): 232.

McAllister, Donald Evan. 1964. The evolution of branchiostegal rays in teleostome fishes. Ph.D. thesis, Department of Zoology, University of British Columbia, Vancouver. xii + 483 pages., 3 figures, 18 plates.

McAllister, D. E. and **E. I. S. Rees.** 1964. A revision of the eelpout genus *Melanostigma* with a new genus and with comments on *Maynea*. National Museum of Canada Bulletin 199, Contributions to Zoology, Paper 5 (1963): 85-110, 9 figures, 3 tables.

McAllister, D. E. 1964. Dans l'Arctique… au bout du monde. Le Jeune Scientifique 3(1): 17-19, 4 figures.

McAllister, D. E. 1964. Distinguishing characters for the sculpins *Cottus bairdii* and *C. cognatus* in eastern Canada. Journal of the Fisheries Research Board of Canada 21(5): 1339-1342, 3 figures, 1 table.

McAllister, D. E. 1964. Fish collections from eastern Hudson Bay. Canadian Field-Naturalist 78(3): 167-178, 8 figures, 1 table.

McAllister, D. E. 1964. Review of: Fishes of the Western North Atlantic *by* H. B. Bigelow et al. Canadian Field-Naturalist 78(3): 194-195.

McAllister, D. E. 1964. Review of: Fish and Wildlife: A Memorial to W. J. K. Harkness, *edited by* J. R. Dymond. Canadian Field-Naturalist, 78(3): 195.

McAllister, D. E., and **S. U. Qadri.** 1965. Fish remains from a 2,500-year-old Lake Superior archaeological site, with notes on previous sites. Natural History Papers, National Museum of Canada 29: 1-8, 6 figures.

McAllister, D. E. 1965. Bibliography of Dr. Wilbert Amie Clemens. Institute of Fisheries, University of British Columbia, Museum Contribution 7: 1-12, portrait.

McAllister, D. E. 1965. Review of: Fishes Occurring in the Fresh Waters of Insular Newfoundland *by* W. B. Scott and E. J. Crossman. Canadian Field-Naturalist 79(1): 72-73.

McAllister, D. E. 1965. Distribution of freshwater fish in northern Canada. The Arctic Circular 16(2): 22-25.

McAllister, D. E. 1965. Review of: Fishes of the Western North Atlantic *by* H. B. Bigelow et al. Canadian Field-Naturalist 79(2): 148-149.

McAllister, D. E. 1965. Type specimens of fishes in the National Museum of Canada with brief historical notes. Natural History Papers, National Museum of Canada 31: 1-13, 2 figures.

McAllister, D. E., and **S. J. Westrheim.** 1965. Widow rockfish, *Sebastodes entomelas*, new to British Columbia waters. Journal of the Fisheries Research Board of Canada 22(6): 1559-1561, 1 figure.

McAllister, D. E. 1966. The form and function of the lateral line in bony fishes. Proceedings of the Nineteenth Meeting of the Canadian Committee on Freshwater Fisheries Research, Appendix H, 1 page.

McAllister, D. E. 1966. Chapter VI. The collecting and preserving of fishes. Pages 152-170, figures 47-50, 1 unnumbered figure *in* Methods of Collecting and Preserving Vertebrate Animals *by* R. M. Anderson. 4th edition, revised. National Museum of Canada Bulletin, 69 (1965): vii + 199 pages, 53 figures.

McAllister, Don E. 1966. Bibliography of the marine fishes of Arctic Canada. Institute of Fisheries, University of British Columbia, Vancouver, Museum Contribution 8: 1-16.

McAllister, D. E. 1966. Review of: A Checklist of Canadian Atlantic Fishes with Keys for Identification *by* W. B. Scott and M. G. Scott. Canadian Field-Naturalist 80(1): 57-58.

McAllister, Don E. 1966. The significance of ventral bioluminescence in fishes *in* Bioluminescence in the Pacific. Proceedings of the Eleventh Pacific Science Congress, Tokyo, 1966. Volume 5, 1 page.

McAllister, D. E., and **D. L. Dineley.** 1966. Review of: Principles of Paleontology. Agnatha, Fishes, *edited by* D. V. Obruchev. Canadian Field-Naturalist 80(2): 112-113.

McAllister, D. E. 1966. Review of: Fishes of the Sea of Japan and neighbouring parts of the Okhotsk and Yellow Seas *by* G. U. Lindberg and M. I. Legeza. Canadian Field-Naturalist 80(2): 113.

McAllister, Don E. 1966. Numerical taxonomy and the smelt family, Osmeridae *in* Freshwater sciences and ichthyology. Proceedings of the Eleventh Pacific Science Congress, Tokyo, 1966. Volume 7, 1 page.

McAllister, D. E. 1966. Review of: Fishes of the Western North Atlantic, Part 5, Order Iniomi and Order Lyomeri *by* various authors. Canadian Field-Naturalist 80(3): 173-174.

McAllister, D. E. 1966. Review of: Catalogue Systématique des Noms de Genres de Poissons Actuels *by* Yves-J. Golvan. Canadian Field-Naturalist 80(3): 175.

McAllister, D. E. 1967. Numerical taxonomy and the smelt family, Osmeridae. Canadian Field-Naturalist 80(4) [1966]: 227-238, 2 figures, 4 tables.

Qadri, S. U., and **D. E. McAllister.** 1967. Fish remains from a 700-year-old southern Ontario archaeological site. Natural History Papers, National Museum of Canada 34: 1-6, 11 figures.

McAllister, D. E. 1967. The significance of ventral bioluminescence in fishes. Journal of the Fisheries Research Board of Canada 24(3): 537-554, 3 figures, 1 table.

McAllister, Don E. 1967. The significance of ventral bioluminescence in fishes. Science Report of the Yokusuka City Museum 13: 5-6. *in*: Symposium on bioluminescence in the Pacific area of the Eleventh Pacific Science Congress.

McAllister, Don E. 1967. The evolution of branchiostegals and associated opercular, gular, and hyoid bones, and the classification of teleostome fishes, living and fossil. Advance Abstracts of Contributions on Fisheries and Aquatic Sciences in India 1(3): 10-11.

McAllister, D. E. 1967. Review of Fishes of the Atlantic Coast of Canada *by* A. H. Leim and W. B. Scott. Canadian Field-Naturalist 81(3): 209-210.

McAllister, D. E. 1968. Review of: Freshwater Fishes of Eastern Canada *by* W. B. Scott. Canadian Field-Naturalist 81(4) [1967]: 296.

McAllister, D. E. 1968. Mandibular pore pattern in the sculpin family Cottidae. National Museum of Canada Bulletin 223. Contributions to Zoology IV: 58-69, 1 figure, 2 tables.

McAllister, D. E. 1968. The evolution of branchiostegals and associated opercular, gular, and hyoid bones, and the classification of teleostome fishes, living and fossil. National Museum of Canada Bulletin 221: xiv + 239 pages, 3 figures, 21 plates, 2 tables, figured end papers.

McAllister, D. E. 1968. Review of: Modes of Reproduction in Fishes *by* Charles M. Breder, Jr. and Donn Eric Rosen. Canadian Field-Naturalist 82(1): 62-63.

McAllister, D. E. 1968. Northern field projects of the National Museum of Natural Sciences, 1968. The Arctic Circular 18(1/2): 33.

McAllister, D. E. 1968. Poisonous and venomous fishes of Canada. Natural History Papers, National Museum of Canada 42: 1-11, 8 figures.

McAllister, D. E. 1968. A list of the fishes of the Ottawa area. Trail & Landscape 2(6): 148-153, 2 photographs.

McAllister, D. E., et **Claude Delisle.** 1968. Le coelacanthe, un fossile vivant. Le Jeune Scientifique 7(2): 30-31, 3 figures.

Faber, Daniel J., and **Don E. McAllister.** 1968. Review of: Development of Fishes of the Chesapeake Bay Region. An Atlas of Egg, Larval, and Juvenile Stages *by* Alice J. Mansueti and Jerry D. Hardy. Canadian Field-Naturalist 82(2): 165-167.

McAllister, D. E. 1969. Review of: Freshwater Fishes of Connecticut *by* Walter R. Whitworth, Peter L. Berrien and Walter T. Keller. Canadian Field-Naturalist 82(4) [1968]: 301.

McAllister, D. E. 1969. Review of: Fishes of the Bahamas and Adjacent Tropical Waters *by* James E. Böhlke and Charles C. G. Chaplin. Canadian Field-Naturalist 82(4) [1968]: 301-302.

McAllister, D. E. 1969. Introduction of tropical fishes into a hotspring near Banff, Alberta. Canadian Field-Naturalist 83(1): 31-35, 2 figures, 1 table.

McAllister, D. E. 1969. Proposed activities of the National Museum of Natural Sciences, 1969. The Arctic Circular 19(2): 38-39.

McAllister, Don E. 1969. Systematic ichthyology. Memorial University of Newfoundland Marine Sciences Research Laboratory. Expert Advisory Group on Marine Sciences Research Needs in Newfoundland Waters, 26-31 August 1968. 3 pages. (Restricted distribution).

McAllister, Don E. 1969. Canada's fish fauna, pages 53-54, 1 figure *in*: Animal Life in Canada Today. 1968 Canada Year Book. Queen's Printer, Ottawa. xvii + 1277 pages. [Les poissons du Canada. Dans: la faune actuel du Canada. L'Annuaire du Canada 1968. L'Imprimeur de la Reine, Ottawa].

McAllister, D. E., and **C. R. Harington**. 1969. Pleistocene grayling, *Thymallus*, from Yukon, Canada. Canadian Journal of Earth Sciences, 6(5): 1185-1190, 5 figures, 1 table.

#**McAllister, Don E.** 1969. Un spécimen unique au Canada. Le Jeune Scientifique, 8(1): 25, photographs.

Bourne, Neil, and **D. E. McAllister.** 1970. The black hagfish, *Eptatretus deani*, from British Columbia. Journal of the Fisheries Research Board of Canada 26(12) [1969]: 3246-3248, 1 figure.

McAllister, D. E. 1970. Arctic activities of the National Museum of Natural Sciences, 1969 and 1970. The Arctic Circular 20(1): 17-18.

McAllister, D. E. 1970. Endangered wildlife – fish *in* Endangered wildlife in Canada. Canadian Wildlife Federation,

Ottawa, pages 12, 15: 2 photographs/La faune en danger – poissons. Dans: La faune en danger au Canada. La Fédération canadienne de la Faune, Ottawa, pages 12, 15; 2 photographies.

McAllister, D. E. 1970. Review of: The Sockeye Salmon, *Oncorhynchus nerka, by* R. E. Foerster. Canadian Field-Naturalist 83(4) [1969]: 414-415.

McAllister, D. E. 1970. Review of L'Alose et le Gaspereau [The American Shad and the Alewife] *by* Jean-Marie Roy. Canadian Field-Naturalist 83(4) [1969]: 419.

McAllister, Don E. 1970. Review of: The structure and relationships of the paracanthopterygian fishes *by* Donn Eric Rosen and Colin Patterson. Copeia 1970(2): 400-401.

McAllister, D. E. 1970. Review of: The structure and relationships of the paracanthopterygian fishes *by* Donn Eric Rosen and Colin Patterson. Quarterly Review of Biology 45(2): 209.

McAllister, D. E. 1970. Rare or endangered Canadian fishes. Canadian Field-Naturalist 84(1): 5-8.

McAllister, D. E. 1970. Review of: Checklist of Canadian Freshwater Fishes with Keys for Identification *by* W. B. Scott and E. J. Crossman. Canadian Field-Naturalist 84(1): 71-72. July 1970

McAllister, D. E. 1970. The fresh and brackish water fishes, Pages 38-43 *in* Fauna of Sable Island and its zoogeographic affinities. National Museum of Natural Sciences, Publications in Zoology 4: vi + 45 pages, 1 table.

McAllister, D. E. 1970. Proposal for aquatic parks and reserves in Canada. Canadian Field-Naturalist 84(2): 97.

McAllister, D. E. 1970. Review of: Olfaction in Fishes *by* Herman Kleerekoper. Canadian Field-Naturalist 84(2): 197-198.

Waldman, M., and **D. E. McAllister.** 1970. Review of: Compléments à l'étude des Poissons Actinoptérygiens du Jurassique français *by* Sylvie Wenz. Canadian Field-Naturalist 84(3): 323-325.

McAllister, D. E. 1970. Review of: Catalogue des espèces de Poissons déposés au Musée de la Station de biologie marine de Grande-Rivière (Gaspé-sud) 1932-1969 *by* Julien Bergeron and Vianney Legendre. Canadian Field-Naturalist 84(3): 327.

McAllister, D. E. 1971. Introduction of tropical fishes into a hotspring near Banff, Alberta. OVAS (Ottawa Valley Aquarium Society) News 1971: 10-14, 2 figures (reprint of 1969 paper).

McAllister, D. E. 1971. Old fourlegs, a "living fossil", an account of the coelacanth fish, *Latimeria chalumnae*. National Museums of Canada, National Museum of Natural Sciences, Odyssey Series 1: 1-25, 4 figures, 7 plates. Le vieux quadrupède, « Fossile vivant », présentation du coelacanthe, *Latimeria chalumnae*. Musée nationaux du Canada, Musée national des Sciences naturelles, Collection Odyssée 1: 1-25, 4 figures, 7 planches.

McAllister, D. E. 1971. Review of: A List of Common and Scientific Names of Fishes from the United States and Canada *by* R. M. Bailey et al.. Canadian Field-Naturalist 85(1): 85.

McAllister, D. E. 1971. Review of: Atlas and Gazetteer of Canada/Atlas et Toponymie du Canada *by* Department of Energy, Mines and Resources. Canadian Field-Naturalist 85(3): 275.

McAllister, Don E. 1971. Review of: Dean Bibliography of Fishes 1968 *by* James W. Atz. Canadian Field-Naturalist 85(3): 275-276.

McAllister, D. E. 1971. Iowa darters (*Etheostoma exile*) spawning at Lac la Peche, Quebec. Trail & Landscape 5(4): 112-113, 2 photographs.

McAllister, D. E. 1972. Review of: Above and Below, a Journey through our National Underwater Parks *by* Helga Sandburg and George Crile, Jr. Canadian Field-Naturalist 85(4) [1971]: 343-344.

McAllister, D. E., and **J. C. Ward.** 1972. The deepwater sculpin, *Myoxocephalus quadricornis thompsoni*, new to Alberta, Canada. Journal of the Fisheries Research Board of Canada 29(3): 344-345.

McAllister, Don E. 1972. FIR [Fish Information Retrieval]. Mudpie (Museum and University Data, Program and Information Exchange) 25:3.

McAllister, Don E., Pierre Jolicoeur, and **Hiroshi Tsuyuki.** 1972. Morphological and myogen comparison of johnny and tessellated darters and their hybrids, genus *Etheostoma*, near Ottawa, Canada. Journal of the Fisheries Research Board of Canada 29(8): 1173-1180, 5 figures, 5 tables.

McAllister, Don E., Anton B. Leere, and **Satya P. Sharma.** 1972. A batch process computer information retrieval and cataloguing system in the fish collection, National Museum of Natural Sciences. Syllogeus, 1:1-20, 5 figures.

Brassard, Léo, et **Don E. McAllister.** 1972. Nouvelle capture du laimargue, *Somniosus microcephalus* (Bloch and Schneider), dans le Fjord du Saguenay. Le Naturaliste canadien 99(4): 441-442, 1 figure.

McAllister, Don E. 1972. Review of: Freshwater Fishes of Northwestern Canada and Alaska *by* J. D. McPhail and C. C. Lindsey. Canadian Field-Naturalist 86(1): 103-105.

McAllister, Don E. 1972. Review of: Kamloops, an angler's study of the Kamloop's trout *by* Steve Raymond. Canadian Field-Naturalist, 86(4): 409-410.

McAllister, Don E. 1972. Review of: The Fisherman's Handbook: A Complete Guide to Fishing in North America *by* John Power and Jeremy Brown. Canadian Field-Naturalist 87(1): 83-84.

McAllister, Don E. 1972. Review of: Freshwater Fishes of Manitoba, checklist and keys *by* Alex N. Fedoruk. Canadian Field-Naturalist, 87(1): 84.

Gruchy, I. M., and **Don E. McAllister.** 1973. A bibliography of the smelt family, Osmeridae. Fisheries Research Board of Canada Technical Report 368 [1972]: ii + 104 pages.

McAllister, Don E. 1973. Variation in midlateral scale number in teleostome fishes. Program of the 53rd Annual Meeting of the American Society of Ichthyologists and Herpetologists, 24 June – 30 June, 1973, University of Costa Rica, San Jose. Supplement: Abstracts, 2 pages.

Kljukanov, V. A., and **D. E. McAllister.** Osmeridae, Pages 158-159 *in* J. C, Hureau and Th. Monod. *Editors*. Clofnam. Check-list of the fishes of the north-eastern Atlantic and of the Mediterranean/Catalogue des poissons de l'Atlantique du nord-est et de la Méditerranée. UNESCO, Paris. Volume I: xxii + 683 pages.

#**McAllister, Don E., Anton B. Leere,** and **Satya P. Sharma.** 1973. A batch process computer information retrieval and cataloguing system in the fish collection, National Museum of Natural Sciences. Decuscope 12(1): 5-13, 5 figures.

McAllister, D. E., and **E. J. Crossman.** 1974. A Guide to the Freshwater Sport Fishes of Canada. National Museums of Canada, National Museum of Natural Sciences, Natural History Series 1: xi + 89 pages, 15 plates. Poisson de pêche sportive d'eau douce du Canada. Musées Nationaux du Canada, Musée national des Sciences naturelles, 1: xi + 91 pages. 15 planches. [dated 1973].

Bleakney, J. S., and **Don E. McAllister.** 1974. Fishes stranded during extreme low tides in Minas Basin, Nova Scotia. Canadian Field-Naturalist 87(4) [1973]: 371-376, 4 figures, 1 table.

McAllister, Don E., and **C. G. Gruchy.** 1974. Review of: Freshwater Fishes of Canada *by* W. B. Scott and E. J. Crossman. Canadian Field-Naturalist 88(2): 241-242.

Gorham, Stanley W., and **Don E. McAllister.** 1974. The shortnose sturgeon, *Acipenser brevirostrum*, in the Saint John River, New Brunswick, Canada, a rare and possibly endangered species. Syllogeus 5: 1-18, 5 figures, 2 tables.

McAllister, Don E., and **Francis R. Cook**, *Editors*. 1974. Programme de la 54^{e} réunion annuelle de la Société Américaine d'Ichthyologie et de Herpétologie/Program of the 54th Annual Meeting of the American Society of Ichthyologists and Herpetologists, Musée National des Sciences Naturelles/National Museum of Natural Sciences, 17 June to 22 June/du 17 au 22 juin 1974, Ottawa. 18+38+18 pages.

McAllister, Don E. 1974. Zoogeography of the marine fishes of Arctic Canada. Programme de la 54^{e} réunion annuelle de la Société Américaine d'Ichthyologie et de Herpétologie/Program of the 54th Annual Meeting of the American Society of Ichthyologists and Herpetologists, Musée National des Sciences Naturelles/National Museum of Natural Sciences, 17 June to 22 June/du 17 au 22 juin 1974, Ottawa, page 22 [abstract].

McAllister, Don E., Brian W. Coad, Peter Rubec, and **Jadwiga Aniskowicz.** 1974. Fishes of Canada's National Capital Region/Poissons de la region de la capitale du Canada. Programme de la 54^{e} réunion annuelle de la Société Américaine d'Ichthyologie et de Herpétologie/Program of the 54th Annual Meeting of the American Society of Ichthyologists and Herpetologists, Musée National des Sciences Naturelles/National Museum of Natural Sciences, 17 June to 22 June/du 17 au 22 juin 1974, Ottawa, pages. 12-13 [abstract}.

McAllister, Don E. 1974. Review of: Hydrographic history and relict fishes of the North-central Great Basin *by* Carl L. Hubbs, Robert Rush Miller and Laura C. Hubbs. Journal of the Fisheries Research Board of Canada 31(9): 1561.

McAllister, Don E,. and **Brian W. Coad.** 1975. Fishes of Canada's National Capital Region/Poissons de la région de la capitale du Canada. Fisheries Research Board of Canada, Miscellaneous Special Publication, 24 [1974]: 1-200, 87 illustrations, (9 colour), 4 figures, 77 maps. [Excerpts published in Trail & Landscape: Introduction 9(4) [1975]: 117-121, 2 figures; Mooneye *Hiodon tergisus* Le Sueur 9(5) [1975]: 146-147, 2 figures; Lake Charr (trout) Salvelinus namayoush (*sic*) (Walbaum) 10(1) [1976]: 20-21, 2 figures; Longnose dace Rhinichthys cataractae (Valenciennes) 10(2) [1976]: 42-43, 2 figures; Tadpole madtom Noturus gyrinus (Mitchill) 10(3) [1976]: 56-57, 2 figures; Brook stickleback Culaea inconstans (Kirtland) 10(4) [1976]: 90-91, 2 figures; Common shiner Notropis cornutus (Mitchill) 10(5) [1976]: 118-119, 2 figures).

Legendre, Vianney, J. G. Hunter, and **Don E. McAllister.** 1975. French, English and scientific names of marine fishes of Arctic Canada/Noms français, anglais et scientifiques des poissons marins de l'Arctique canadien. Syllogeus 7: 1-15, 1 figure, 1 map.

McAllister, D. E. 1975. Review of: The Urohyal in Fishes *by* Takaya Kusaka. Journal of the Fisheries Research Board of Canada 32(2): 325.

Gruchy, C. G., and **D. E. McAllister**. 1975. Review of: Pacific Fishes of Canada *by* J. L. Hart. Canadian Field-Naturalist 89(1): 93-94.

McAllister, Don E. 1975. Review of: Interrelationships of Fishes, *edited by* P. H. Greenwood, R. S. Miles, and Colin Patterson. Transactions of the American Fisheries Society 104(2): 427-428.

McAllister, Don E. 1975. Fish collections from the Otish Mountain region, central Québec, Canada. Syllogeus 8: 1-12, 1 figure, 1 table.

McAllister, Don E., and **John E. Randall.** 1975. A new species of centrolophid fish from Easter Island and Rapa Iti Island in the South Pacific. National Museum of Natural Sciences, National Museums of Canada, Publications in Biological Oceanography, 8: ix + 6 pages. 3 figures, 1 table.

McAllister, Don E. 1975. The compleat museum minicomputer cataloguing and research system. Program of the American Society of Ichthyologists and Herpetologists, 55th Annual Meeting, June 8-14, 1975, Williamsburg, Virginia. page 102 [abstract].

McAllister, Don E. 1975. A traction function in swimming for fish scales. Program of the American Society of Ichthyologists and Herpetologists, 55th Annual Meeting, June 8-14, 1975, Williamsburg, Virginia. page 103 [abstract].

McAllister, Don E. 1975. Scale number variation in teleostome fishes. Thirteenth Pacific Science Congress, Record of the Proceedings, Vancouver, Volume 1: 59 [abstract].

#**McAllister, Don E.** 1975. The ecology of the marine fishes of Arctic Canada, page 33 [abstract] *in* Proceedings of the Circumpolar Conference on Northern Ecology, September 15-18, 1975, Ottawa.

McAllister, Don E. 1975. A new species of Arctic eelpout, *Lycodes sagittarius*, from the Beaufort Sea, Alaska, and the Kara Sea, USSR (Pisces: Zoarcidae). National Museum of Natural Sciences, National Museums of Canada, Publications in Biological Oceanography 9: 1-16, 3 figures, 2 tables.

Gilhen, John, C. G. Gruchy, and **Don E. McAllister.** 1976. The sheepshead, *Archosargus probatocephalus*, and the feather blenny, *Hypsoblennius hentzi*, two additions to the Canadian Atlantic ichthyofauna. Canadian Field-Naturalist 90(1): 42-46, 2 figures, 1 table.

McAllister, Don E., and **Jadwiga Aniskowicz.** 1976. Vertebral number in North American sculpins of the *Myoxocephalus quadricornis*-complex. Journal of the Fisheries Research Board of Canada 33(12): 2792-2799, 3 figures, 2 tables.

McAllister, Don E. 1976. Review of: Opération coelacanthe *by* Jean Anthony. Canadian Field-Naturalist 90(4): 511-512.

McAllister, D. E. 1977. Ecology of the marine fishes of Arctic Canada, pages II49-II65, 2 figures *in* Proceedings of the Circumpolar Conference on Northern Ecology, September 15-18, 1975, National Research Council of Canada, Ottawa. Section II, Marine Ecology. viii + 648 pages.

McAllister, Don E., and **C. G. Gruchy**. 1977. Status and habitat of Canadian fishes in 1976, pages 151-157, 5 figures, *in* T. Mosquin and C. Suchal. *Editors*. Proceedings of the Symposium on Canada's Threatened Species and Habitats. Canadian Nature Federation, Special Publication, Ottawa, 6: 1-185.

McAllister, Don E., and **Brian W. Coad.** 1977. A test evaluating phenetic and cladistic relationships of Nearctic genera of Cyprinidae. Program of the American Society of

Ichthyologists and Herpetologists, 57th Annual Meeting, 19-25 June 1977, Gainesville, Florida. 2 pages [abstract].

McAllister, D. E., and **A. P. Andriashev.** 1977. *Ophidium parrii* Ross, 1826 (Pisces); application for suppression Z.N.(S.) 1578. Bulletin of Zoological Nomenclature 34(1): 58-60.

McAllister, Don E. 1977. Review of: Opération coelacanthe par J. Anthony. Le Naturaliste canadien 103(5): 491-492.

McAllister, Don E. 1977. Review of: Répartition géographique des poissons, leur abondance relative et bathymétrie de la région du Lac Saint-Pierre by Gérard Massé et Jean-René Mongeau; Cartes de répartition géographique des espèces de poissons au sud du Québec, d'après les inventaires ichthyologiques effectués de 1963 à 1972 *by* Jean-René Mongeau; Les poissons de la région de Montréal, la pêche sportive et commerciale, les ensemencements, les frayères, la contamination par le mercure et les PCB *by* Jean-René Mongeau et Gérard Massé. Canadian Field-Naturalist 91(3): 330.

McAllister, Don E. 1977. Review of: Méthodes de pêche expérimentale, en eau douce, à l'usage du biologiste et du technicien de la faune *by* Jean-René Mongeau. Canadian Field-Naturalist 91(3): 330.

McAllister, Don E. 1977. Review of: The Anatomy of Fishes. Parts I and II *by* Wilhelm Harder. Canadian Field-Naturalist 91(3): 331.

McAllister, Don E., Robert Murphy, and **John Morrison.** 1978. The compleat minicomputer cataloging and research system for a museum. Curator 21(1): 63-91, 14 figures, 3 tables.

McAllister, Don E., et **C. Lavett Smith.** 1978. Mensuration morphologiques, dénombrements méristiques et taxonomie du coelacanthe, *Latimeria chalumnae*. Le Naturaliste canadien 105(2): 63-76, 10 figures, 3 tableaux.

Copeman, Douglas G., and **Donald E. McAllister.** 1978. Analysis of the effect of transplantation on morphometric and meristic characters in lake populations of the rainbow smelt, *Osmerus mordax* (Mitchill). Environmental Biology of Fishes 3(3): 253-259, 4 figures, 1 table.

McAllister, Don E., R. Murphy, et **J. Morrison.** 1978. Méthodes modernes de gestion et d'exploitation des collections. Revue de Travaux de l'Institut Scientifique et Technique des Pêches maritimes,40(3 et 4) [1976]:461-480, 9 figures, 1 tableau.

McAllister, Don E., and **Brian W. Coad.** 1978. A test between relationships based on phenetic and cladistic taxonomic methods. Canadian Journal of Zoology 56(10): 2198-2210, 2 figures, 1 table.

#**McAllister, Don E.**, and **Douglas G. Copeman.** 1978. The effects of lake transplantation on morphometric and meristic characters in the rainbow smelt, *Osmerus mordax* (Mitchill). Newsletter/Bulletin of the Canadian Society of Environmental Biologists (Proceedings of the 19th Annual Meeting, January 4-6, 1978) 35(2): 45.

Andriashev, A. P., and **Don E. McAllister.** 1978. Status of the presumed zoarcid fish *Ophidium parrii* and its identity with *Liparis koefoedi*, Liparidae. Copeia, 1978(4): 710-712, 1 figure.

McAllister, Nancy, and **Don E. McAllister.** 1979. Review of: Précis de Zoologie: vertébrés. 2. Reproduction, biologie, évolution et systématique. Agnathes, poissons, amphibiens et reptiles *by* Pierre-P. Grassé. Canadian Field-Naturalist 92(4) [1978]: 410.

McAllister, Don E. 1979. Review of "Lexique anglais-français, Termes techniques à l'Usage des Biologistes" by Jean Vaillancourt. Canadian Field-Naturalist 93(2): 208.

McAllister, Don E. 1979. Measuring device extends beyond fish. Canadian Research 12(7): 9, 13.

McAllister, D. E., and **C. G. Gruchy.** 1979. Status and habitat of Canadian fishes. International Wildlife 9(2): 28A-28H [insert: Wildlife Report. The Canadian Scene].

Faber, Daniel J., and **Don E. McAllister**, 1979. Review of: Development of Fishes of the Mid-Atlantic Bight. An Atlas of egg, larval and juvenile stages. Journal of the Fisheries Research Board of Canada 36(6): 706-707.

McAllister, Don E. 1979. Review of: Anatomie de *Latimeria chalumnae*. Tome III. Appareil digestif – appareil respiratoire - appareil urogénital – glandes endocrines – appareil circulatoire – teguments – écailles – conclusions générales" *by* J. Millot, J. Anthony and D. Robineau. Journal of the Fisheries Research Board of Canada 36(6): 707-708.

Champagne, Donald E., C. R. Harington, and **Don E. McAllister.** 1979. Deepwater sculpin, *Myoxocephalus thompsoni* (Girard) from a Pleistocene nodule, Green Creek, Ontario, Canada. Canadian Journal of Earth Sciences, 16(8): 1621-1628, 3 figures.

Gilbert, Carter R., Charles H. Hocutt, Robert E. Jenkins, Don E. McAllister, and **Jay R. Stauffer, Jr.** 1980. Atlas of North American Freshwater Fishes. North Carolina State Museum of Natural History, Raleigh. x + 867 pages, numerous maps and figures.

Kenneth, Able W., and **Don E. McAllister.** 1981. Revision of the snailfish genus *Liparis* from Arctic Canada. Canadian Bulletin of Fisheries and Aquatic Sciences, 208 (1980): viii + 52 pages, 27 figures, 7 tables.

McAllister, Don E. 1981. Review of: Order in Living Organisms: a systems analysis of evolution *by* Rupert Riedl. Canadian Field-Naturalist, 95(1): 120.

McAllister, Don E., and **R. Jon Planck.** 1981. Capturing fish measurements and counts with calipers and probe interfaced with a computer or pocket calculator. Canadian Journal of Fisheries and Aquatic Sciences 38(4): 466-470, 4 figures.

McAllister, Don E., and **Denis St-Onge.** 1981. Postglacial fossil fishes from Coppermine River, Northwest Territories, Canada. Canadian Field-Naturalist 95(2): 203-205.

Gilhen, John, and **Don E. McAllister**, 1981. First Nova Scotian and second Canadian record of Atlantic fanfish, *Pterycombus brama* Fries, 1837 (Bramidae). Proceedings of the Nova Scotian Institute of Science 30(3/4) [1980]: 191-193, 1 figure.

McAllister, Don E. 1981. Review of: Charrs: salmonid fishes of the genus *Salvelinus, edited by* Eugene K. Balon. Canadian Field-Naturalist, 95(2): 220-221.

McAllister, Don E., M. Eric Anderson, and **J. G. Hunter.** 1981. Deep-water eelpouts, Zoarcidae, from Arctic Canada and Alaska. Canadian Journal of Fisheries and Aquatic Sciences 38(7): 821-839, 5 figures.

McAllister, Don E. 1981. Review of: The Freshwater Fishes of Alaska *by* James E. Morrow. Canadian Field-Naturalist 95(3): 375.

McAllister, Don E., Stephen L. Cumbaa, and **C. R. Harington.** 1981. Pleistocene fishes (*Coregonus*, *Osmerus*, *Microgadus*, *Gasterosteus*) from Green Creek, Ontario, Canada. Canadian Journal of Earth Sciences 18(8): 1356-1364, 3 figures.

Cumbaa, Stephen L., Don E. McAllister and **Richard E. Morlan.** 1981. Late Pleistocene fish fossils of *Coregonus*, *Stenodus*, *Thymallus*, *Catostomus*, *Lota*, and *Cottus* from the Old Crow basin, northern Yukon, Canada. Canadian Journal of Earth Sciences, 18(11): 1740-1754, 8 figures.

Jean, Yves, Alex E. Peden, and **Don E. McAllister.** 1981. English, French and scientific names of Pacific fish of Canada/Noms français, anglais et scientifiques des poissons de la côte du Pacifique du Canada. British Columbia Provincial Museum Heritage Record 13: 1-51, 1 figure.

McAllister, Don E. 1982. Review of: Les salmonidés des eaux de la Plaine de Montréal: 1. Historique, 1534-1977 et 2. Biometrie, biogéographie, 1970-1975, et registre des pêches 1941-1976 *by* Vianney Legendre, Jean-René Mongeau, Jean Leclerc et Jocelyne Brisebois. Canadian Field-Naturalist 95(4): 486-487.

Gilhen, John, and **Don E. McAllister.** 1982. First Canadian record of yellowfin bass, *Anthias nicholsi* Firth, taken off Nova Scotia. Proceedings of the Nova Scotian Institute of Science 31(3/4) [1981]: 251-254, 1 figure.

McAllister, Don E. 1982. Review of: A Handbook of Fish Habitat Protection on Forest Lands in British Columbia *by* D. A. A. Toews and M. J. Brownlee. Canadian Field-Naturalist 96(2): 240.

McAllister, Don E., and **Frederick W. Schueler.** 1982. Review of Systematics and Biogeography, Cladistics and Vicariance *by* Gareth Nelson and Norman Platnick. Canadian Field-Naturalist 96(2): 246-247.

Godkin, C. M., W. J. Christie, and **D. E. McAllister.** 1982. Problems of species identity in the Lake Ontario sculpins, *Cottus bairdi* and *C. cognatus*. Canadian Journal of Fisheries and Aquatic Sciences 39(10): 1373-1382, 6 figures, 4 tables.

Shih, C. T., and **Don E. McAllister.** 1982. Review of: New Chinese fish books [Freshwater fishes of Guangxi/Fishes of Tumen River]. Copeia 1982(4): 979-980.

Steigerwald, Michèle Bélanger, and **Don E. McAllister.** 1982. List of the Canadian marine fish species in the National Museum of Natural Sciences, National Museums of Canada/Liste des espèces de poissons marins du Canada au Musée national des sciences naturelles, Musées nationaux du Canada. Syllogeus 41: 1-30, 2 figures.

Lanteigne, Jacqueline, and **Don E. McAllister.** 1983. The pygmy smelt, *Osmerus spectrum* Cope, 1870, a forgotten sibling species of eastern North American fish. Syllogeus 45:1-32, 6 figures, 3 tables.

McAllister, Don E. 1983. An introduction to minicomputers in museums. Syllogeus 44:105-136, 14 figures.

McAllister, Don E., and **C. T. Shih.** 1983. Review of: The Fishes of the Islands in the South China Sea by South China Sea Fisheries Institute et al. Canadian Field-Naturalist 97(1): 133-134.

McAllister, Don E., and **C. T. Shih.** 1983. Review of: A study of the lateral-line canals system and that of Lorenzini ampullae and tubules of elasmobranchiate fishes of China *by* Yuanting T. Chu and Ching Wen Meng. Canadian Field-Naturalist 97(1): 134.

#**McAllister, D. E.** 1983. Biogeography of marine fishes of Arctic Canada, pages 14-16 in Proceedings of the Thirty-sixth Meeting of the Canadian Conference for Fisheries Research held at Winnipeg, January 3 and 4, 1983.

Hunter, J. G., Shirley T. Leach, Don E. McAllister, and **Michèle Bélanger Steigerwald.** 1984. A distributional atlas of records of the marine fishes of Arctic Canada in the National Museums of Canada and Arctic Biological Station. Syllogeus 52: 1-35, 3 text figures, 21 plates.

McAllister, D. 1984. Osmeridae, Pages 399-402, 3 figures, 3 maps *in* Fishes of the North-eastern Atlantic and the Mediterranean/Poissons de l'Atlantique du Nord-Est et de la Méditerranée, *edited by* P. J. P. Whitehead, M.-L. Bauchot, J.-C. Hureau, J. Nielsen, and E. Tortonese. UNESCO, Paris. Volume 1: 1-510.

McAllister, Don E., Brad J. Parker, and **Paul M. McKee.** 1985. Rare, endangered and extinct fishes in Canada. Syllogeus 54: 1-192, 60 figures.

Gilhen, John, Charles G. Gruchy, and **Don E. McAllister.** 1985. The cubera snapper, *Lutjanus cyanopterus* (Cuvier) (Pisces: Lutjanidae) new to Nova Scotia and Canada. Proceedings of the Nova Scotian Institute of Science 34(2) [1984]: 177-180, 1 figure.

Gilhen, John, and **Don E. McAllister.** 1985. The tripletail, *Lobotes surinamensis*, new to the fish fauna of the Atlantic coast of Nova Scotia and Canada. Canadian Field-Naturalist 99(1): 116-118, 1 figure.

McAllister, Don E. 1985. Review of: Vanishing Fishes of North America *by* R. Dana Ono, James D. Williams, and Anne Wagner. Canadian Field-Naturalist 99(2): 274-275.

McAllister, Don E. 1985. Review of: A Dictionary of Ecology, Evolution, and Systematics *by* R. J. Lincoln, G. A. Boxshall, and P. F. Clark. Canadian Field-Naturalist 99(2): 278-279.

McAllister, Don E. 1985. Review of: Evolution of Fish Species Flocks *by* Anthony A. Echelle and Irv Kornfield. Canadian Journal of Fisheries and Aquatic Sciences 42(8): 1443-1444.

McAllister, D. E. 1985. Endangered animals, page 571-572, 2 figures *in* The Canadian Encyclopedia, Volume I, A-For. xxxv + 1-666 pages. Hurtig Publishers, Edmonton, Alberta [this, and the next two articles, appeared also in subsequent editions of the Canadian Encyclopedia].

McAllister, D. E. 1985. Smelt, page 1707 *in* The Canadian Encyclopedia, Volume III, Pat-Z. Index. Pages 1373-2089. Hurtig Publishers, Edmonton, Alberta.

McAllister, D. E. 1985. Sturgeon, page 1768, 1 figure *in* The Canadian Encyclopedia, Volume III, Pat-Z. Index. Hurtig Publishers, Edmonton, Alberta.

McAllister, Don E., and **Brian W. Coad.** 1985. Review of: Fishes of the North-Eastern Atlantic and the Mediterranean/Poissons de l'Atlantique du Nord-Est et de la Méditerranée *edited by* P. J. P. Whitehead, M.-L. Bauchot, J.-C. Hureau, J. Nielsen, and E. Tortonese. Canadian Journal of Fisheries and Aquatic Sciences 42(11): 1852.

McAllister, Don E. 1985. Review of: Caribbean Fish Life: Index to the local and scientific names of the marine fishes and fishlike invertebrates of the Caribbean area (tropical western central Atlantic Ocean) *by* Jacques S. Zaneveld. Canadian Field-Naturalist 99(3): 459-460.

McAllister, Don E. 1985. Review of: The American Darters *by* Robert A. Kuehne and Roger W. Barbour. Canadian Field-Naturalist 99(3): 460-461.

McAllister, Don E. 1985. Review of: Scientific Studies on Hudson and James Bays/Recherches sur la baie d'Hudson et la baie James. Volume I and II. *Edited by* I. P. Martini. Canadian Field-Naturalist 99(3): 464-465. 31 December 1985.

McAllister, Don E., Steven P. Platania, Frederick W. Schueler, M. Elizabeth Baldwin, and **David S. Lee.** 1986. Ichthyofaunal patterns on a geographic grid, pages 17-51, 9 figures, 1 table *in* The Zoogeography of North American

Freshwater Fishes. *Edited by* Charles H. Hocutt and E. O. Wiley. John Wiley & Sons, New York. xiii + 866 pages.

Crossman, E. J., and **Don E. McAllister.** 1986. Zoogeography of freshwater fishes of the Hudson Bay drainage, Ungava Bay and the Arctic Archipelago, pages 53-104, 7 figures, 2 tables *in* The Zoogeography of North American Freshwater Fishes. *Edited by* Charles H. Hocutt, and E. O. Wiley. John Wiley & Sons, New York. xiii + 866 pages.

McAllister, Don E. 1986. Technique of making fish illustration 16: gyotaku, direct prints from fish specimens. Environmental Biology of Fishes 15(2): 90, 1 figure.

McAllister, Don E. 1986. Use of small nets instead of cyanide for collecting aquarium fishes in the Philippines. Program of the 66th Annual Meeting of the American Society of Ichthyologists and Herpetologists, Victoria, British Columbia June 1986. 1 page. [abstract].

McAllister, Don E. 1986. Review of: An atlas of distribution of the freshwater fish families of the world *by* T. M. Berra. Experimental Biology 45(1): 65-66.

McAllister, Don E. 1986. Obituary of Vadim Dimitrovitch Vladykov, 1898-1986. Environmental Biology of Fishes 15(4): 241-242, 1 photograph.

McAllister, D. E., and **W. B. Scott.** 1986. Vadim Dmitrivitch Vladykov 1898-1986. Transactions of the Royal Society of Canada, Series V, Volume 1: 348-351, 1 photograph.

Renaud, Claude B., Lawrence I. Speers, Sami U. Qadri, and **Don E. McAllister.** 1986. Biochemical evidence of speciation in the cod genus *Gadus*. Canadian Journal of Zoology 64(7): 1563-1566, 1 figure, 3 tables.

McAllister, Don E., and **Peter J. Rubec.** 1986. Aquino government approves program to end *cyanide* use in the Philippines for the collection of tropical marine fishes. Environmental Biology of Fishes 17(4): 315-317.

McAllister, Don E., and **Brian W. Coad.** 1986. Review of: Fishes of the North-Eastern Atlantic and the Mediterranean/ Poissons de l'Atlantique du Nord-Est et de la Méditerranée *edited by* P. J. P. Whitehead, M.-L. Bauchot, J.-C. Hureau, J. Nielsen, and E. Tortonese. Canadian Field-Naturalist 100(1): 152-153.

Prouse, N. J., and **Don E. McAllister.** 1986. The glacial eelpout, *Lycodes frigidus*, from the Arctic Canadian Basin, new to the Canadian ichthyofauna. Canadian Field-Naturalist 100(3): 325-329, 2 figures.

McAllister, Don E. 1986. Review of: The Trumpeter: voices from the Canadian ecophilosophy network *edited by* Alan R. Drengson. Canadian Field-Naturalist 100(3): 455.

Waller, Robert, and **Don E. McAllister.** 1986. A spot test for distinguishing formalin from alcohol solutions, pages. 93-99, 4 figures, 1 table. *In* Proceedings of the 1985 Workshop on Care and Maintenance of Natural History Collections. *Edited by* Janet Waddington and David M. Rudkin. Royal Ontario Museum, Life Sciences Miscellaneous Publications. v + 121 pages.

McAllister, Don E., *Editor and partial author*. 1987. Sea Wind, Bulletin of the International Marinelife Alliance, Ottawa 1(1): 1-32, 18 figures.

McAllister, Don E., and **Jane Topping.** 1987. Triton's trumpet shell – predator of coral reef destroying Crown of Thorns starfish? Sea Wind, Bulletin of the International Marinelife Alliance, Ottawa 1(1): 6-9, 2 figures.

McAllister, Don E., and **Michèle Bélanger Steigerwald.** 1987. Bibliography of the marine fishes of Arctic Canada 1771-1985. Canadian Manuscript Report of Fisheries and Aquatic Sciences, 1909(1986): v + 108 pages, 2 figures.

McAllister, Don E., Vianney Legendre, et **J. G. Hunter.** 1987. Liste des noms inuktitut (esquimaux), français, anglais et scientifiques des poissons marins du Canada arctique/List of Inuktitut (Eskimo), French, English and Scientific names of marine fishes of Arctic Canada. Rapport manuscrit canadien des sciences halieutiques et aquatiques, 1932: v + 106 pages, 1 figure.

McAllister, Don E., *Editor and partial author*. 1987. Sea Wind, Bulletin of the International Marinelife Alliance, Ottawa, 1(2):1-32, 19 figures.

McAllister, Don E. 1987. The co-operative gene. Sea Wind, Bulletin of the International Marinelife Alliance, Ottawa 1(2): 25-26, 2 figures.

McAllister, Don E. 1987. Review of: Sea Fishes of the World (Indo-Pacific region) *by* Hajime Masuda and Gerald R. Allen. Sea Wind Bulletin of the International Marinelife Alliance, Ottawa 1(2): 28-29.

#**McAllister, Don E.** 1987. A computerized working world fish list. American Society of Ichthyologists and Herpetologists, Albany, New York, June 1987, page 66 [abstract].

Waller, Robert, and **Don E. McAllister.** 1987. A spot test to distinguish formalin from alcohol solutions. Curator 30(3): 240-249, 3 figures, 1 table.

McAllister, Don E., *Editor and partial author*. 1987. Sea Wind, Bulletin of the International Marinelife Alliance, Ottawa 1(3): 1-32, 21 figures.

McAllister, Don E. 1987. How many fish species in the sea? Sea Wind, Bulletin of the International Marinelife Alliance, Ottawa 1(3): 17-18, 1 figure.

McAllister, Don E. 1987. Collecting aquarium fish with other chemicals than cyanide? Sea Wind, Bulletin of the International Marinelife Alliance, Ottawa 1(3): 19-20, 1 figure.

McAllister, Don E. 1987. Review of: Our Common Future *by* Gro Harlem Brundtland. Sea Wind, Bulletin of the International Marinelife Alliance, Ottawa 1(3): 22-24.

McAllister, Don E. 1987. Mine pollution at Marinduque Island in the Philippines. Sea Wind, Bulletin of the International Marinelife Alliance, Ottawa 1(3): 26-27, 2 figures.

McAllister, Don E. 1987. The co-operative gene. Corals. Sea Wind, Bulletin of the International Marinelife Alliance, Ottawa 1(3): 28-29, 3 figures.

McAllister, D. E. 1987. Status of the central stoneroller, *Campostoma anomalum*, in Canada. Canadian Field-Naturalist 101(2): 213-218, 2 figures.

McAllister, D. E. 1987. Status of the blackstripe topminnow, *Fundulus notatus*, in Canada. Canadian Field-Naturalist 101(2): 219-225, 3 figures.

McAllister, Don E., *Editor and partial author.* 1987. Sea Wind, Bulletin of the International Marinelife Alliance, Ottawa 1(4): 1-35, 20 figures.

McAllister, Don E. 1987. A test for cyanide-caught fish. Sea Wind, Bulletin of the International Marinelife Alliance, Ottawa 1(4): 6-9, 2 figures.

McAllister, Don E. 1987. The biggest great white shark. Sea Wind, Bulletin of the International Marinelife Alliance, Ottawa 1(4): 11-14, 1 figure.

McAllister, Don E. 1987. Review of Haiku *edited by* Dorothy Howard and Andre. Sea Wind, Bulletin of the International Marinelife Alliance, Ottawa 1(4): 30-31.

#**McAllister, D. E.** 1987. Priorities for ichthyological research in the Canadian Arctic Archipelago. Program and Abstracts, The Canadian Arctic Islands, Canada's Missing Dimension, An International Meeting sponsored by the National Museum of Natural Sciences, Ottawa, Canada, November 21-24, 1987, page 77 [abstract].

McAllister, Don E., *Editor and partial author.* 1988. Sea Wind, Bulletin of the International Marinelife Alliance, Ottawa 2(1): 1-36, 15 figures.

McAllister, Don E. 1988. Review of: NAGA, The ICLARM Quartery (*sic*) *edited by* Jay L. Maclean. Sea Wind, Bulletin of the International Marinelife Alliance, Ottawa 2(1): 17-18.

McAllister, Don E. 1988. Shiraho coral reef report submitted. Sea Wind, Bulletin of the International Marinelife Alliance, Ottawa 2(1): 20-23, 2 figures.

McAllister, Don E. 1988. Review of: Sea fishes of southern Australia *by* Barry Hutchins and Roger Swainston. Sea Wind, Bulletin of the International Marinelife Alliance, Ottawa 2(1): 30-31.

McAllister, Don E. 1988. Review of: Endangered species, Canada's disappearing wildlife *by* Clive Roots. Sea Wind, Bulletin of the International Marinelife Alliance, Ottawa 2(1): 31.

Planck, R. Jon, Don E. McAllister, and **Angus T. McAllister.** 1988. Shiraho Coral Reef & the proposed new Ishigaki Island Airport, Japan with a review of the coral reefs of the Ryukyu Archipelago, Japan. International Marinelife Alliance, Ottawa 220 pages, 21 figures.

McAllister, Don E. 1988. A glowing future for marine aquarium fishes… the peaceful Philippine revolution under the seas. Tropical Fish Hobbyist 36(12): 84-86, 3 colour photographs.

McAllister, Don E. 1988. Vadim Dimitrievitch Vladykov: life of an ichthyologist. Environmental Biology of Fishes 23(1/2): 9-20, 9 figures.

Coad, Brian W., Don E. McAllister, and **Claude B. Renaud.** 1988. Bibliography of Vadim D. Vladykov: scientific publications and manuscript reports 1923-1988. Environmental Biology of Fishes 23(1/2): 21-36.

Renaud, Claude B., and **Don E. McAllister.** 1988. Taxonomic status of the extinct Banff longnose dace, *Rhinichthys cataractae smithi*, of Banff National Park, Alberta. Environmental Biology of Fishes 23(1/2): 95-113, 4 figures, 1 table.

McAllister, Don E., and **Edward Kott.** *Guest Editors.* 1988. On lampreys and fishes: a memorial anthology in honor of Vadim D. Vladykov. Developments in Environmental Biology of Fishes, 8: 1-162 pages, 69 figures, 20 tables [reprinted from Environmental Biology of Fishes 23(1/2)].

McAllister, Don E., *Editor and partial author.* 1988. Sea Wind, Bulletin of the International Marinelife Alliance, Ottawa 2(2): 1-36, 21 figures.

McAllister, Don E. 1988. Review of: The Crown of Thorns Starfish *edited by* Leon Zann and Elaine Eager. Sea Wind, Bulletin of the International Marinelife Alliance, Ottawa 2(2): 29-30.

McAllister, Don E. 1988. Review of: Ellisella the coral *by* Katherine Muzik and Makota Wada. Sea Wind, Bulletin of the International Marinelife Alliance, Ottawa 2(2): 31-32.

Coad, Brian W., Don E. McAllister, and **D. Max Blouw.** 1988. Morphological diagnosis of the white stickleback of Canada. Program and Abstracts, 75th Annual Meeting of the American Society of Ichthyologists and Herpetologists, University of Michigan, Ann Arbor, June 24-29, 1988, page 76 [abstract].

McAllister, D. E. 1988. Verzamelen van aquariumvissen met andere middelen dan cyanide? Het Zee-Aquarium 38(6): 126-127.

McAllister, Don E. 1988. Review of: Biology of the Arctic Charr: Proceedings of the International Symposium on Arctic Charr *edited by* Lionel Johnson and Bonnie Burns. Canadian Field-Naturalist 101(4)[1987]: 642-643.

McAllister, Don E. 1988. Review of: Fishes of the Northeastern Atlantic and the Mediterranean/Poissons de l'Atlantique du Nord-Est et de la Méditerranée *by* P. J. P. Whitehead, M.-L. Bauchot, J.-C. Hureau, J. Nielsen, and E. Tortonese. Canadian Field-Naturalist 101(4) [1987]: 646.

McAllister, Don E. 1988. Review of: The Inland Fishes of New York State by C. Lavett Smith. Canadian Field-Naturalist 101(4)[1987]: 646-647. 19 July 1988

McAllister, Don E. 1988. Review of: Biology of the Arctic charr: Proceedings of the International Symposium on Arctic Charr *edited by* L. Johnson, B. Burns. Experimental Biology 47(3): 182.

McAllister, Don E., *Editor and partial author.* 1988. Sea Wind, Bulletin of the International Marinelife Alliance, Ottawa 2(3): 1-36, 20 figures.

McAllister, Don E. 1988. The high price of periodicals & Third World countries. What price knowledge? Sea Wind, Bulletin of the International Marinelife Alliance, Ottawa 2(3): 22-24.

McAllister, Don E. 1988. Review of: Coastal fishes of the Pacific northwest *by* Andy Lamb and Phil Edgell. Sea Wind, Bulletin of the International Marinelife Alliance, Ottawa 2(3): 28.

McAllister, Don E. 1988. Review of: Smith's Sea Fishes *by* Margaret M. Smith and P. C. Heemstra. Sea Wind, Bulletin of the International Marinelife Alliance, Ottawa 2(3): 29-30.

McAllister, Don E. 1988. Review of: Towards a second green revolution, from chemical to new biological technologies in agriculture in the tropics *edited by* G. B. Marini-Bettolo. Sea Wind, Bulletin of the International Marinelife Alliance, Ottawa 2(3): 30.

McAllister, Don E. 1988. Review of: The natural way of farming *by* Masanobu Fukuoka. Sea Wind, Bulletin of the International Marinelife Alliance, Ottawa 2(3): 30.

McAllister, Don E. 1988. Review of: Proceedings of the Symposium on Subtropical-Tropical Seagrasses of the Southeastern United States *edited by* M. J. Durako, R. C. Phillips, and Roy R. Lewis, III. Sea Wind, Bulletin of the International Marinelife Alliance, Ottawa 2(3): 31.

McAllister, Don E. 1988. Review of: Smith's sea fishes by M. M. Smith and P. C. Heemstra. Experimental Biology 47: 226.

McAllister, Don E. 1988. Environmental, economic and social costs of coral reef destruction in the Philippines. Regional Research Workshop and International Symposium on the Conservation and Management of Coral Reefs and Mangrove Ecosystems. Regional MAB/COMAR IV Meeting and First University of the Ryukyus International Symposium, 24 September-4 October, 1987. 38 pages, 7 figures.

McAllister, Don E. 1988. About the Philippines. Pet Business, Orlando 14(11): 29.

McAllister, Don E., *Editor and partial author.* 1988. Sea Wind, Bulletin of the International Marinelife Alliance, Ottawa 2(4): 1-36, 17 figures.

McAllister, Don E. 1988. Old fourlegs, the coelacanth. Sea Wind, Bulletin of the International Marinelife Alliance, Ottawa 2(4): 6-9, 1 figure.

McAllister, Don E. 1988. Acid rain and the sea. Sea Wind, Bulletin of the International Marinelife Alliance, Ottawa 2(4): 13-15.

McAllister, Don E. 1988. Unsung national hero discovered. Sea Wind, Bulletin of the International Marinelife Alliance, Ottawa 2(4): 26.

McAllister, Don E. 1988. What one person can do! Sea Wind, Bulletin of the International Marinelife Alliance, Ottawa 2(4): 28.

McAllister, Don E. 1988. Review of: Guide illustré de la faune aquatique dans l'art grec *by* Jean Delorme and Charles Roux. Sea Wind, Bulletin of the International Marinelife Alliance, Ottawa 2(4): 29-31.

McAllister, Don E. 1988. Review of: ICOD info. The Newsletter of the International Centre for Ocean Development. Sea Wind, Bulletin of the International Marinelife Alliance, Ottawa 2(4): 32-33.

McAllister, Don E. 1988. Review of: The freshwater fishes of Europe, Volume 1, part 1. Petromyzontiformes *edited by* J. Holcik. Experimental Biology 48(1): 50.

McAllister, Don E., *Editor and partial author*. 1989. Sea Wind, Bulletin of the International Marinelife Alliance, Ottawa 3(1): 1-36, 14 figures.

McAllister, Don E. 1989. Aquaculture, yes, no, maybe? Sea Wind, Bulletin of the International Marinelife Alliance, Ottawa 3(1): 13-18.

McAllister, Don E. 1989. Listen to the wind. Sea Wind, Bulletin of the International Marinelife Alliance, Ottawa 3(1): 24.

McAllister, Don E. 1989. What one person can do. Sea Wind, Bulletin of the International Marinelife Alliance, Ottawa 3(1): 25.

McAllister, Don E. 1989. An alternative to Canada's proposed nuclear submarine fleet. Sea Wind, Bulletin of the International Marinelife Alliance, Ottawa 3(1): 26-28.

McAllister, Don E. 1989. Formation of IUCN Coral Fish Protection Committee announced. Marine Fish Monthly 3(12): 42.

McAllister, Don E., C. R. Harington, S. L. Cumbaa, and **Claude B. Renaud**. 1989. Paleoenvironmental and biogeographic analyses of fossil fishes in peri-Champlain Sea deposits in eastern Canada, pages 241-258, 12 figures, 1 table *in* The Late Quaternary Development of the Champlain Sea Basin. *Edited by* N. R. Gadd. Geological Association of Canada, Special Paper 35.

McAllister, Don. 1989. Threats to coral fishes. Species, Newsletter of the Species Survival Commission 12: 33-34, 2 figures.

McAllister, Don E., *Editor and partial author*. 1989. Sea Wind, Bulletin of the International Marinelife Alliance, Ottawa 3(2): 1-36, 10 figures.

McAllister, Don E. 1989. One globe, links between freshwater, sea and air. Thinking eco-system-atic-ally. Sea Wind, Bulletin of the International Marinelife Alliance, Ottawa 3(2): 5-6, 1 figure.

McAllister, Don E. 1989. What can one person do? Sea Wind, Bulletin of the International Marinelife Alliance, Ottawa 3(2): 16.

McAllister, Don E. 1989. Review of: Coral Reefs of Florida *by* Gilbert L. Voss. Sea Wind, Bulletin of the International Marinelife Alliance, Ottawa 3(2): 30-31.

McAllister, Don E. 1989. Review of: Ocean Realm. Sea Wind, Bulletin of the International Marinelife Alliance, Ottawa 3(2): 31.

McAllister, Don E. 1989. Review of: Peces nicaragüenses *by* Jaime Villa. Sea Wind, Bulletin of the International Marinelife Alliance, Ottawa 3(2): 33-34.

McAllister, Don E. 1989. Review of: World symposium on fishing gear and fishing vessel design. Sea Wind, Bulletin of the International Marinelife Alliance, Ottawa 3(2): 34-35.

McAllister, Don E. 1989. Review of: Corals and coral reefs in the Caribbean. A manual for students *by* Stafford A. Griffith and Eugenie William. Sea Wind, Bulletin of the International Marinelife Alliance, Ottawa 3(2): 35.

McAllister, Don E., *Editor and partial author*. 1989. Sea Wind, Bulletin of the International Marinelife Alliance, Ottawa 3(3): 1-36, 11 figures.

McAllister, Don E. 1989. Seahorses. Sea Wind, Bulletin of the International Marinelife Alliance, Ottawa 3(3): 6, 1 figure.

McAllister, Don E. 1989. Ship's ballast water and introduction of exotic fauna and flora: biological pollution. Sea Wind, Bulletin of the International Marinelife Alliance, Ottawa 3(3): 16-17, 1 figure.

McAllister, Don E. 1989. What can I do? Sea Wind, Bulletin of the International Marinelife Alliance, Ottawa 3(3): 18.

McAllister, Don E. 1989. Ozone layer depletion and sealife. Sea Wind, Bulletin of the International Marinelife Alliance, Ottawa 3(3): 24-27, 1 figure.

McAllister, Don E. 1989. Review of: Coral reef fishes of Aruba, Bonaire and Curaçao *by* Dr. Wil Nagelkerken. Sea Wind, Bulletin of the International Marinelife Alliance, Ottawa 3(3): 27-28.

McAllister, Don E. 1989. Review of: Sharks of Polynesia *by* R. H. Johnson. Sea Wind, Bulletin of the International Marinelife Alliance, Ottawa 3(3): 28-29.

McAllister, Don E. 1989. Review of: California Waterfront Age *edited by* Rasa Gustatis. Sea Wind, Bulletin of the International Marinelife Alliance, Ottawa 3(3): 29-30.

McAllister, Don E. 1989. Review of: Underwater farming by George S. Fichter. Sea Wind, Bulletin of the International Marinelife Alliance, Ottawa 3(3): 30-31.

McAllister, Don E. 1989. Review of Marine Turtle Newsletter *edited by* Nat B. Frazer. Sea Wind, Bulletin of the International Marinelife Alliance, Ottawa 3(3): 34.

McAllister, Don E. 1989. Environmental, economic and social costs of coral reef destruction in the Philippines. Galaxea 7(1988): 161-178, 7 figures.

McAllister, Don E., *Editor and partial author*. 1989. Sea Wind, Bulletin of the International Marinelife Alliance, Ottawa 3(4): 1-36, 12 figures.

McAllister, Don E. 1989. Coral reef rugosity and health, a quick automated field measure. Sea Wind, Bulletin of the International Marinelife Alliance, Ottawa 3(4): 25-29, 2 figures.

McAllister, Don E. 1989. What one person can do. Sea Wind, Bulletin of the International Marinelife Alliance, Ottawa 3(4): 31-32.

McAllister, Don E. 1989. Review of: Peces de las aguas continentales de Costa Rica *by* William A. Bussing. Sea Wind, Bulletin of the International Marinelife Alliance, Ottawa 3(4): 33.

McAllister, Don E. 1989. Review of: The IDRC Reports *by* International Development Research Centre, Ottawa. Sea Wind, Bulletin of the International Marinelife Alliance, Ottawa 3(4): 33-34.

McAllister, Don E. 1989. Review of: NAGA. The ICLARM Quarterly. Sea Wind, Bulletin of the International Marinelife Alliance, Ottawa, 3(4): 34.

McAllister, Don E. 1989. Review of: Environmental impact assessment and environmental policy in Japan" by Brendan F. D. Barrett. Sea Wind, Bulletin of the International Marinelife Alliance, Ottawa 3(4): 35.

McAllister, Don E. 1989. Coral reefs and oceans. Paper presented at the "Our Commonworld" Conference, Toronto, 1989. MS, 6 pages.

#**McAllister, D. E.** 1989. Fishes and benthic invertebrates of Hudson Strait. Atelier sur le Detroit d'Hudson Strait Workshop, Novembre 9-10 November 1989, Holiday Inn Pointe-Claire. Supplementary pages, 36A-36D [abstract].

Williams, Jack E., James E. Johnson, Dean A. Hendrickson, Salvador Contreras-Balderas, James D. Williams, Miguel Navarro-Mendoza, Don E. McAllister, and **James E. Decon.** 1990. Fishes of North America endangered, threatened, or of special concern: 1989. Fisheries 14(6) [1989]: 2-20, 4 colour plates, 2 tables, 1 appendix.

McAllister, Don E., *Editor and partial author*. 1990. Sea Wind, Bulletin of the International Marinelife Alliance, Ottawa 4(1): 1-40, 15 figures.

McAllister, Don E. 1990. Review of: The conservation of nature *by* the Nature Conservancy of Japan. Sea Wind, Bulletin of the International Marinelife Alliance, Ottawa 4(1): 33-34.

McAllister, Don E. 1990. Review of: A citizen's guide to plastics in the ocean: more than a litter problem *by* Kathryn J. O'Hara. Sea Wind, Bulletin of the International Marinelife Alliance, Ottawa 4(1): 35.

McAllister, Don E. 1990. Review of: Reservoir fishery management and development in Asia *Edited by* Seno S. De Sylva. Sea Wind, Bulletin of the International Marinelife Alliance, Ottawa 4(1): 37-38.

McAllister, Don E., *Editor and partial author*. 1990. Sea Wind, Bulletin of the International Marinelife Alliance, Ottawa 4(2): 1-36, 19 figures.

McAllister, Don E. 1990. Review of: Directory of Environmental NGO's in the Asia-Pacific Region *by* Sahabat Alam Malaysia. Sea Wind, Bulletin of the International Marinelife Alliance, Ottawa 4(2): 33.

McAllister, Don E. 1990. Review of: Poisoners of the seas *by* K. A. Gourlay. Sea Wind, Bulletin of the International Marinelife Alliance, Ottawa 4(2): 34.

#**McAllister, Don E.** 1990. A national aquarium for the Philippines. Let's Conserve Our Natural Resources. Part 36. Greenfields, Makati, Manila 20(1): 8-10.

McAllister, Don E., *Editor and partial author*. 1990. Sea Wind, Bulletin of the International Marinelife Alliance, Ottawa 4(3): 1-36, 16 figures.

McAllister, Don E. 1990. Bannerfishes, genus *Heniochus*. Sea Wind, Bulletin of the International Marinelife Alliance, Ottawa 4(3): 8-9, 2 figures.

McAllister, Don E. 1990. Review of: The freshwater fishes of Western Borneo (Kalimantan Barat, Indonesia) *by* Tyson R. Roberts. Sea Wind, Bulletin of the International Marinelife Alliance, Ottawa 4(3): 32-33.

McAllister, Don E. 1990. Review of: Ecos. January 1990 issue of a new ecology magazine. Sea Wind, Bulletin of the International Marinelife Alliance, Ottawa 4(3): 34-35.

McAllister, Don E. 1990. Review of: Atlantic Fishes of Canada *by* W. B. Scott and M. G. Scott. Canadian Field-Naturalist 103(4): 618-619. 26 September.

McAllister, Don E., *Editor and partial author*. 1990. Sea Wind, Bulletin of the International Marinelife Alliance, Ottawa 4(4): 1-36, 17 figures.

McAllister, Don E. 1990. Monoculture vs polyculture. Sea Wind, Bulletin of the International Marinelife Alliance, Ottawa 4(4): 8-9.

McAllister, Don E. 1990. Power of the pen. Sea Wind, Bulletin of the International Marinelife Alliance, Ottawa 4(4): 24-25.

McAllister, Don E. 1990. The ocean as a dump. Sea Wind, Bulletin of the International Marinelife Alliance, Ottawa, 4(4): 27-28.

McAllister, Don E. 1990. What one person can do. Sea Wind, Bulletin of the International Marinelife Alliance, Ottawa 4(4): 29.

McAllister, Don E. 1990. Review of: COT Newsletter. Sea Wind, Bulletin of the International Marinelife Alliance, Ottawa 4(4): 34.

McAllister, Don E. 1990. Review of: Canopy International. Sea Wind, Bulletin of the International Marinelife Alliance, Ottawa 4(4): 34-35.

McAllister, Don E. 1990. Priorities for ichthyological research in the Canadian Arctic Archipelago, pages 512-515, 5 figures, *in* Canada's Missing Dimension. Science and History in the Canadian Arctic Islands. Volume II. *Edited by* C. R. Harrington Canadian Museum of Nature, Ottawa. Pages 444-855.

McAllister, D. E. 1990. Diversity and biology of invertebrates and fish, pages 120-126 *in* Compte Rendu d'un Atelier: Études de l'écosytème marin du détroit d'Hudson/ Proceedings of workshop: Marine ecosystem studies in Hudson Strait, Novembre 9-10 November, 1989, Montréal, Québec. *Edited by* J. A. Percy. Canadian Technical Report of Fisheries and Aquatic Sciences 1770: xiv + 175 pages.

McAllister, Don E. 1990. A List of the Fishes of Canada/ Liste des poissons du Canada. Syllogeus 64: 1-310, 32 figures.

Houston, J., and **D. E. McAllister.** 1990. Status of the Bering wolffish, *Anarhichas orientalis*, in Canada. Canadian Field-Naturalist 104(1): 20-23, 3 figures.

Houston, J., and **D. E. McAllister.** 1990. Status of the blackline prickleback, *Acantholumpenus mackayi*, in Canada. Canadian Field-Naturalist 104(1): 24-28, 3 figures.

McAllister, Don E., *Editor and partial author*. 1991. Sea Wind, Bulletin of Ocean Voice and International Marinelife Alliance, Ottawa 5(1): 1-36, 18 figures.

McAllister, Don E. 1991. A glimpse of wild sea otters! Sea Wind, Bulletin of Ocean Voice and International Marinelife Alliance, Ottawa 5(1): 8-9, 1 figure.

McAllister, Don E. 1991. What is the status of the world's coral reef fishes? Sea Wind, Bulletin of Ocean Voice and International Marinelife Alliance, Ottawa 5(1): 14-18, 2 figures.

McAllister, Don E. 1991. What is a coral reef worth? Sea Wind, Bulletin of Ocean Voice and International Marinelife Alliance, Ottawa, 5(1): 21-24.

Howlett, David H., and **Don E. McAllister.** 1991. PADI's scuba diver environmental A.W.A.R.E. Program. Sea Wind, Bulletin of Ocean Voice and International Marinelife Alliance, Ottawa 5(1): 24-25.

McAllister, Don E., *Editor and partial author/Editeur et auteur en partie*. 1991. Canadian Biodiversity, Ottawa 1(1): 1-48, numerous text figures; Bulletin canadien de la biodiversité, Ottawa 1(1): 1-52, plusieurs schémas dans le texte.

McAllister, Don E. 1991. What is biodiversity? Canadian Biodiversity, Ottawa 1(1): 4-6, 1 figure; Qu'est-ce que la biodiversité? Bulletin canadien de la biodiversité, Ottawa 1(1): 4-6, 1 figure.

McAllister, Don E. 1991. Why save biodiversity? Rationales and ethics. Canadian Biodiversity, Ottawa 1(1): 8-13, 2 figures; Vers la rationalisation de la conservation de la biodiversité. Bulletin canadien de la biodiversité, Ottawa 1(1): 8-14, 2 figures.

Schueler, Frederick W., and **Don E. McAllister.** 1991. Maps of the number of tree species in Canada: A pilot GIS study of tree biodiversity. Part 1. Canadian Biodiversity, Ottawa 1(1): 22-29, 4 figures. Cartes de nombre d'espèces d'arbres au Canada. Une étude SIG pilote de la biodiversité des arbres: partie 1. Bulletin canadien de la biodiversité, Ottawa 1(1): 23-30, 4 figures.

McAllister, Don E. 1991. Review of: Biodiversity Network News *by* The Nature Conservancy, Arlington. Canadian Biodiversity, Ottawa, 1(1): 44. Bulletin canadien de la biodiversité, Ottawa 1(1): 46-47.

#**McAllister, Don E.** 1991. Terumbu Karang Kita (Save our Coral Reefs). Ocean Voice International, Inc., Ottawa, World Wildlife Fund (Irian Jaya) and Indonesian Forestry Department, Irian Jaya, Indonesia. 78 pages, 58 figures.

McAllister, Don E., and **Callum Roberts.** 1991. GIS grids, butterflyfish (Chaetodontidae) and coral reef habit at biodiversity. Research Results Conference des Resultats de Recherche, Canadian Museum of Nature, Ottawa. March 1991 Mars, page 54 [abstract].

McAllister, Don E., *Editor and partial author.* 1991. Sea Wind, Bulletin of Ocean Voice International, Ottawa 5(2): 1-36, 13 figures.

McAllister, Don E. 1991. Questions about the impact of trawling. Sea Wind, Bulletin of Ocean Voice International, Ottawa 5(2): 28-32, 1 figure.

McAllister, Don E. 1991. Review of Green Teacher *by* Green Teacher, Toronto. Sea Wind, Bulletin of Ocean Voice International, Ottawa 5(2): 35.

McAllister, Don E., *Editor and partial author/Editeur et auteur en partie.* 1991. Canadian Biodiversity, Ottawa 1(2): 1-44, numerous text figures; Bulletin canadien de la biodiversité, Ottawa 1(2): 1-48, schémas dans le texte plusieurs.

McAllister, Don E., and **Erich Haber.** 1991. Western yew – precious medicine. Canadian Biodiversity, Ottawa 1(2): 2-4, 2 figures.; L'if de l'Ouest, source d'un médicament précieux. Bulletin canadien de la biodiversité, Ottawa 1(2): 2-4, 2 figures.

Haber, Erich, and **Don E. McAllister.** 1991. The Canadian Biodiversity Data Bank. Canadian Biodiversity, Ottawa 1(2): 16-19, 3 figures. La banque canadienne de donneés sur la biodiversité. Bulletin canadien de la biodiversité, Ottawa, 1(2): 16-19, 3 figures.

McAllister, Don E. 1991. Review of: Green Teacher *by* Green Teacher, Toronto. Canadian Biodiversity, Ottawa 1(2): 38-39; Bulletin canadien de la biodiversité, Ottawa 1(2): 41.

#**Mosquin, Theodore,** and **Don E. McAllister.** 1991. Canadian biodiversity: A census and an appraisal. Report for the Canadian Centre for Biodiversity, Canadian Museum of Nature, Ottawa. 77 + 18 pages, tables.

McAllister, Don E., *Editor and partial author.* 1991. Sea Wind, Bulletin of Ocean Voice International, Ottawa 5(3): 1-36, 12 figures.

McAllister, Don E. 1991. The First owes the Third World a trillion dollars. Sea Wind, Bulletin of Ocean Voice International, Ottawa, 5(3): 14-20.

McAllister, Don E. 1991. Questions on ocean impacts of James and Hudson Bay hydro projects. Sea Wind, Bulletin of Ocean Voice International, Ottawa 5(3): 22-30, 2 figures.

McAllister, Don E. 1991. Review of: The Green List/La Liste Verte. A guide to Canadian environmental organizations and agencies by the Canadian Environmental Network. Sea Wind, Bulletin of Ocean Voice International, Ottawa 5(3): 32-33.

McAllister, Don E., *Editor and partial author/Editeur et auteur en partie.* 1991. Canadian Biodiversity, Ottawa 1(3): 1-52, numerous text figures; Bulletin canadien de la biodiversité, Ottawa 1(3): 1-56, schémas dans le texte plusieurs.

McAllister, Don E. 1991. Estimating the pharmaceutical values of forests, Canadian and tropical. Canadian Biodiversity, Ottawa 1(3): 16-25. Une estimation de la valeur pharmaceutique des forêts canadiennes et tropicales. Bulletin canadien de la biodiversité, Ottawa 1(3): 17-27.

McAllister, Don E. 1991. Review of: The Green List/La Liste Verte. A guide to Canadian environmental organizations and agencies *by* the Canadian Environmental Network, Ottawa. Canadian Biodiversity, Ottawa 1(3): 47. Revue de "La Liste verte/The Green List. Le répertoire environnemental du Canada. Réseau canadien de l'environnement, Ottawa. Bulletin canadien de la biodiversité, Ottawa 1(3): 50-51.

McAllister, Don E. 1991. Review of: Tumivut. The cultural magazine of the Nunavik Inuit *by* the Avataq Cultural Institute, Inukjuak. Canadian Biodiversity, Ottawa 1(3): 49-50; Revue de: Tumivut. La revue culturelle des Inuit du Nunavik *par* Institut culturel Avataq, Inukjuak. Bulletin canadien de la biodiversité, Ottawa 1(3): 53-54.

McAllister, Don E. 1991. The secret activities of the Canadian Museum of Nature. Sea Pen (Vancouver Public Aquarium) 35(3): 13-14.

McAllister, Don E. 1991. How green is your school? Ocean Voice International, Ottawa. 16 pages, illustrated (reprinted 1993).

Edge, Thomas A., Don E. McAllister, and **Sami U. Qadri.** 1991. Meristic and morphometric variation between the endangered Acadian whitefish, *Coregonus huntsmani*, and the lake whitefish, *Coregonus clupeaformis*, in the Canadian Maritime Provinces and the State of Maine, USA. Canadian Journal of Fisheries and Aquatic Sciences 48(11): 2140-2151, 8 figures, 3 tables.

McAllister, Don E., *Editor and partial author.* 1991. Sea Wind, Bulletin of Ocean Voice International, Ottawa 5(4): 1-36, 15 figures.

McAllister, Don E. 1991. Measuring Arctic Ocean icepack shrinkage and warming: The planetary solar mirror and global thermostat. Sea Wind, Bulletin of Ocean Voice International, Ottawa 5(4): 19-24, 1 figure.

McAllister, Don E. 1991. Fish printing: Environmentally friendly work for women in coastal communities. Sea Wind, Bulletin of Ocean Voice International, Ottawa 5(4): 24-26, 1 figure.

McAllister, Don E. 1991. Review of: Women in Natural Resources. Sea Wind, Bulletin of Ocean Voice International, Ottawa 5(4): 31-32.

McAllister, Don E., Charles Anderson, and **Noel Alfonso.** 1992. Guide to Selected Fishes of the Maldives. International Centre for Ocean Development, Halifax. 92 pages, numerous text figures.

McAllister, Don E., *Editor and partial author/Editeur et auteur en partie.* 1992. Canadian Biodiversity, Ottawa 1(4): 1-52, numerous text figures; Bulletin canadien de la biodiversité, Ottawa 1(4): 1-56, schémas dans le texte plusieurs.

McAllister, Don E., and **Peter G. Whiting.** 1992. Biodiversity gold – a gift of First Nation North Americans to the

planet. Canadian Biodiversity, Ottawa 1(4): 33-35. L'or de la biodiversité: un cadeau des premiers habitants de l'Amérique du Nord à la Terre. Bulletin canadien de la biodiversité, Ottawa 1(4): 39-41.

McAllister, Don E. 1992. Review of: Earthkeeper, Canada's environmental magazine. Canadian Biodiversity, Ottawa 1(4): 49; Bulletin canadien de la biodiversité, Ottawa 1(4): 54-55.

McAllister, Don E., *Editor and partial author*. 1992. Sea Wind, Bulletin of Ocean Voice International, Ottawa 6(1): 1-40, 12 figures.

McAllister, Don E. 1992. Review of: Aquatic Survival. Bulletin of the Aquatic Conservation Network. Sea Wind, Bulletin of Ocean Voice International, Ottawa 6(1): 13-14.

McAllister, Don E., *Editor and partial author/Editeur et auteur en partie*. 1992. Canadian Biodiversity, Ottawa 2(1): 1-52, numerous text figures. Bulletin canadien de la biodiversité, Ottawa, 2(1): 1-52, schémas dans le texte plusieurs.

McAllister, Don E. 1992. Review of: Fight for the forest. Chico Mendes, in his own words. Canadian Biodiversity. Ottawa 2(1): 43-44; Revue de Fight for the forest. Chico Mendes en ses propres mots. Bulletin canadien de la biodiversité, Ottawa 2(1): 43-44.

McAllister, Don E. 1992. Review of: Canadian sources of environmental information/Sources canadiennes d'information sur l'environnement. Canadian Biodiversity, Ottawa 2(1): 43-44 ; Bulletin canadien de la biodiversité, Ottawa 2(1): 44.

McAllister, Don. 1992. The fading of Florida's coral splendor. The Ottawa Citizen, 7 March 1992.

McAllister, Don E., *Editor and partial author*. 1992. Sea Wind, Bulletin of Ocean Voice International, Ottawa 6(2): 1-40, 25 figures.

Ansula, Alejandro C., and **Don E. McAllister.** 1992. Fishing with explosives in the Philippines. Sea Wind, Bulletin of Ocean Voice International, Ottawa 6(2): 6-12, 3 figures.

McAllister, Don E. 1992. Investing in the Earth Summit – Creative options for paying. Sea Wind, Bulletin of Ocean Voice International, Ottawa 6(2): 23-27, 1 figure.

McAllister, Don E. 1992. Marine biodiversity: Sea urchins. Sea Wind, Bulletin of Ocean Voice International, Ottawa 6(2): 32-33, 1 figure.

McAllister, Don E. 1992. Review of: Coral reefs *edited by* Z. Dubinsky. Sea Wind, Bulletin of Ocean Voice International, Ottawa,6(2): 34-36.

McAllister, Don E. 1992. Review of: World fishes, important to North Americans. Exclusive of species from continental waters of United States and Canada *by* C. Richard Robins (Chairperson). Sea Wind, Bulletin of Ocean Voice International, Ottawa 6(2): 37-38.

McAllister, Don E. 1992. Review of: At home in the coral reef *by* Katy Muzik. Sea Wind, Bulletin of Ocean Voice International, Ottawa, 6(2): 38-39.

McAllister, Don E., *Editor and partial author/Editeur et auteur en partie*. 1992. Canadian Biodiversity, Ottawa 2(2): 1-44, numerous text figures; Bulletin canadien de la biodiversité, Ottawa 2(2): 1-52, schémas dans le texte plusieurs.

McAllister, Don E., and **Kenneth Dalton,** 1992. How global warming affects species survival. Canadian Biodiversity, Ottawa 2(2): 7-14, 1 figure : Le réchauffement du globe et la survie des espèces. Bulletin canadien de la biodiversité, Ottawa 2(2): 8-15, 1 figure.

McAllister, Don E. 1992. Antifreezes for crops and engines? Canadian Biodiversity, Ottawa 2(2):26-27, 1 figure. De l'antigel pour les récoltes et les moteurs. Bulletin canadien de la biodiversité, Ottawa 2(2): 25-26, 1 figure.

McAllister, Don. 1992. A glimpse of Earth's richness. Earthkeeper 2(6): 28-33, 4 figures.

McAllister, Don E. 1992. Review of: Profile of higher education in Canada/Profile de l'enseignement supérieur au Canada *by* Department of the Secretary of State, Ottawa.

McAllister, Don E., *Editor and partial author*. 1992. Sea Wind, Bulletin of Ocean Voice International, Ottawa 6(3): 1-40, 7 figures, 5 tables.

McAllister, Don E. 1992. What can I do? Clean beaches, clean world, and pen power. Sea Wind, Bulletin of Ocean Voice International, Ottawa 6(3): 22-25, 1 figure.

McAllister, Don E. 1992. Review of: 1992 Directory of Women in Environment *by* WorldWIDE Network Inc., Washington. Sea Wind, Bulletin of Ocean Voice International, Ottawa 6(3): 35.

McAllister, Don E., *Editor and partial author/Editeur et auteur en partie*. 1992. Canadian Biodiversity, Ottawa 2(3): 1-56, numerous text figures. Bulletin canadien de la biodiversité, Ottawa 2(3): 1-60, schémas dans le texte plusieurs.

McAllister, Don E. 1992. Review of: The state of Canada's environment *by* Environment Canada, Ottawa. Canadian Biodiversity, Ottawa, 2(3): 43-45; Revue de L'État de l'environnement au Canada par Environnement Canada, Ottawa. Bulletin canadien de la biodiversité, Ottawa 2(3): 47-49.

McAllister, Don E. 1992. Review of: 1992 Directory of Women in Environment *by* WorldWIDE Network, Inc., Washington. Canadian Biodiversity, Ottawa 2(3): 52; Bulletin canadien de la biodiversité, Ottawa 2(3): 59.

McAllister, Don E. 1992. GIS, gyo-taku and nets in the conservation of corals, clams and coral fishes, pages 517-520. 1992 AAZPA (American Association of Zoological Parks and Aquariums) Annual Conference, Toronto, Canada, September 13-17, 1992.

McAllister, Don E., *Editor and partial author*. 1992. Sea Wind, Bulletin of Ocean Voice International, Ottawa 6(4): 1-32, 14 figures.

McAllister, Don E. 1992. Lead-free, environmentally-friendly fishing weights. Sea Wind, Bulletin of Ocean Voice International, Ottawa, 6(4): 6-7, 2 figures.

McAllister, Don E. 1992. Star sand from southern Japan. Sea Wind, Bulletin of Ocean Voice International, Ottawa 6(4): 10-11, 3 figures.

McAllister, Don E., and **Jaime Baquero.** 1992. Art live rock – an environmentally friendly alternative to collecting corals and wild live rock for marine aquaria. Sea Wind, Bulletin of Ocean Voice International, Ottawa 6(4): 20-23.

McAllister, Don E. 1992. Marine biodiversity: jewel lanternfish, *Lampanyctus crocodilus*. Sea Wind, Bulletin of Ocean Voice International, Ottawa 6(4): 25-26, 2 figures.

McAllister, Don E. 1992. Review of: Guide to the marine sport fishes of Atlantic Canada and New England *by* Brian W. Coad. Sea Wind, Bulletin of Ocean Voice International, Ottawa 6(4): 27-28.

McAllister, Don E. 1992. Saving ocean ecosystems by conserving forests through use of solar energy. Sea Wind, Bulletin of Ocean Voice International, Ottawa 6(4): 29-31, 2 figures.

McAllister, Don E., *Editor and partial author/Editeur et auteur en partie*. 1992. Canadian Biodiversity, Ottawa 2(4): 1-52, numerous text figures; Bulletin canadien de la biodiversité, Ottawa 2(4): 1-52, schémas dans le texte plusieurs.

McAllister, Don E. 1992. A green path from sea to sea. Canadian Biodiversity, Ottawa 2(4): 17-21, 5 figures; Un sentier de verdure d'un océan à l'autre. Bulletin canadien de la biodiversité, Ottawa 2(4): 14-18, 4 figures.

McAllister, Don E. 1992. A basic biodiversity reference library. Canadian Biodiversity, Ottawa 2(4): 22-28; Une bibliothèque de références sur la biodiversité. Bulletin canadien de la biodiversité, Ottawa 2(4): 19-26.

McAllister, Don E. 1992. Biodiversity distinguished from Biological Resources. Canadian Biodiversity, Ottawa 2(4): 29, 4 figures; Biodiversité ou ressources biologiques? Bulletin canadien de la biodiversité, Ottawa 2(4): 27, 4 figures.

McAllister, Don E. 992. Lead-free fishing weights. Canadian Biodiversity, Ottawa 2(4): 30-31, 4 figures. Pesées sans plomb pour lignes à pêche. Bulletin canadien de la biodiversité, Ottawa 2(4): 28-29, 4 figures.

McAllister, Don E. 1992. Breakthrough in alcohol-producing bacteria – the "alcorobe." A model/lesson for eco-friendly harnessing of microorganisms. Canadian Biodiversity, Ottawa 2(4): 32-35, 1 figure. Une nouvelle bactérie alcooligène: l'alcorobe ou Un modèle, ou même une leçon, d'utilisation écologique de microorganismes. Bulletin canadien de la biodiversité, Ottawa 2(4): 30-33, 1 figures.

McAllister, Don E. 1992. Review of: Tek Talk. A newsletter on traditional ecological knowledge by Canadian Museum of Nature, Ottawa. Canadian Biodiversity, Ottawa 2(4): 41-42. Bulletin canadien de la biodiversité, Ottawa 2(4): 40-41.

McAllister, Don E. 1992. Review of: The nature of southeast Alaska *by* Rita M. O'Clair, Robert H. Armstrong, and Richard Carstensen. Canadian Biodiversity, Ottawa 2(4): 47-48; Bulletin canadien de la biodiversité, Ottawa 2(4): 47-48.

McAllister, Don E. 1992. Review of: Forestry on the hill *by* the Canadian Forestry Association, Ottawa; Revue de: Forestry on the hill *par* l'Association forestière canadienne, Ottawa. Canadian Biodiversity, Ottawa 2(4): 48-49; Bulletin canadien de la biodiversité, Ottawa 2(4): 48-49.

McAllister, Don E. 1992. Review of: The fishes of Alberta *by* Joseph S. Nelson and Martin J. Paetz. Canadian Biodiversity, Ottawa 2(4): 49-50; Bulletin canadien de la biodiversité, Ottawa 2(4): 49-50.

McAllister, Don E. 1992. Review of: Global Environment Facility, a bulletin on the Global Environment Facility *by* the World Bank, Washington. Canadian Biodiversity, Ottawa 2(4): 50-51. Bulletin canadien de la biodiversité, Ottawa 2(4): 50-51.

McAllister, Don E. 1992. The variety of life on Earth. A presentation to the Standing Committee on the Environment, House of Commons, 23 November 1992. MS, 10 pages.

McAllister, Don E., *Editor and partial author*. 1993. Sea Wind, Bulletin of Ocean Voice International, Ottawa 7(1): 1-36, 9 figures.

McAllister, Don E. 1993. A pilot biodiversity inventory of the Bahamas. Sea Wind, Bulletin of Ocean Voice International, Ottawa 7(1): 20-21, 1 figure.

McAllister, Don E., *Editor and partial author/Editeur et auteur en partie*. 1993. Global biodiversity, Ottawa 3(1): 1-48, numerous text figures. La biodiversité mondiale, Ottawa 3(1): 1-48, schémas dans le texte plusieurs.

McAllister, Don E. 1993. Is the hidden tree-fungus partnership in crisis? Global biodiversity, Ottawa 3(1): 32-34, 2 figures: Un vaste réseau souterrain de champignons nourrit les forêts. Cette symbiose est-elle menacée? La biodiversité mondiale, Ottawa 3(1): 33-35, 2 figures.

McAllister, Don E. 1993. Review of: Breeds & breeders guide to minority livestock breeds in Canada *by* Joywin-Farm Rare Breeds Conservancy Inc., Marmora. Global biodiversity, Ottawa 3(1): 41-42; La biodiversité mondiale, Ottawa 3(1): 42-43.

McAllister, Don E. 1993. Review of: 50 simple things your business can do to save the Earth *by* The Earth Works Group, Berkeley. Global biodiversity, Ottawa 3(1): 43. La biodiversité mondiale, Ottawa 3(1): 44-45.

McAllister, Don E. 1993. Review of: Biology International. The News Magazine of the International Union of Biological Sciences (IUBS), Paris. Global biodiversity, Ottawa 3(1): 44; Revue de: Biology International. Le magazine d'information de l'Union internationale des sciences biologiques (UISB). La biodiversité mondiale, Ottawa 3(1): 45.

McAllister, Don E. 1993. Review of: A global partnership. Canada and the Conventions of the United Nations Conference on Environment and Development (UNCED) *by* the Standing Committee on the Environment, House of Commons, Canada. Global biodiversity, Ottawa, 3(1): 44-45; Revue de: Un partenariat à l'échelle de la planète *par* le Canada et les Conventions de la Conférence des Nations Unies sur l'environnement et le développement (CNUED). La Biodiversité mondiale, Ottawa 3(1): 45-46.

McAllister, Don E. 1993. Review of: Earth in balance. Ecology and the human spirit *by* Senator Al Gore. Global biodiversity, Ottawa 3(1): 45. La biodiversité mondiale, Ottawa 3(1): 46-47.

McAllister, Don E., *Editor and partial author*. 1993. Sea Wind, Bulletin of Ocean Voice International, Ottawa 7(2): 1-36, 19 figures.

McAllister, Don E., and **Elisabeth Janssen.** 1993. Alternate livelihoods and community fisheries management by Atlantic coast fishers: Options when fish stocks and habitat are exhausted. Sea Wind, Bulletin of Ocean Voice International, Ottawa 7(2): 2-14, 3 figures.

McAllister, Don E. 1993. Power of the pen. Sea Wind, Bulletin of Ocean Voice International, Ottawa 7(2): 24-25.

McAllister, Don E. 1993. Review of: The by-catch of shrimp trawl fisheries *by* N. L. Andrew and J. G. Pepperell. Sea Wind, Bulletin of Ocean Voice International, Ottawa 7(2): 34-35.

McAllister, Don E. 1993. Review of: Diodon. Newsletter of the Mauritius Marin (*sic*) Conservation society. Sea Wind, Bulletin of Ocean Voice International, Ottawa 7(2): 34-35.

McAllister, Don E., *Editor and partial author/Editeur et auteur en partie*). 1993. Global biodiversity, Ottawa, 3(2): 1-48, numerous text figures; La biodiversité mondiale, Ottawa 3(2): 1-48, schémas dans le texte plusieurs.

McAllister, Don E. 1993. How much land is there on Earth? For people? For nature? Global biodiversity, Ottawa 3(2): 6-7, 1 figure; Combien d'espace habitable y a-t-il sur la Terre? La biodiversité mondiale, Ottawa 3(2): 6-7, 1 figure.

Jarzen, David M., and **Don E. McAllister,** 1993. Love in the plant world benefits the whole world. Global biodiversity, Ottawa 3(2): 15-19, 8 figures. L'amour chez les végétaux profite à tous; La biodiversité mondiale, Ottawa 3(2): 16-19, 47, 6 figures.

McAllister, Don E. 1993. Roots of the Earth. Global biodiversity, Ottawa, 3(2): 25-26, 1 figure; Les racines de la Terre. La biodiversité mondiale, Ottawa 3(2): 25-26, 1 figure.

McAllister, Don E. 1993. Review of: Traditional Ecological Knowledge. Concepts and cases *edited by* Julian T. Inglis. Global biodiversity, Ottawa 3(2): 37. La biodiversité mondiale, Ottawa 3(2): 37-38.

McAllister, Don E. 1993. Review of: Cumulative Environmental Effects Bulletin *by* Environment Canada, Hull. Global biodiversity, Ottawa 3(2): 38; Revue de: Bulletin sur les effets environnementaux cumulatifs *par* Environnement Canada, Hull. La biodiversité mondiale, Ottawa 3(2): 38.

McAllister, Don E. 1993. Review of: Freshwater fish. Canadian Nature Guide *by* Henry W. Robinson. Global biodiversity, Ottawa 3(2):44-45. La biodiversité mondiale, Ottawa 3(2): 44.

McAllister, Don. 1993. Forests are *more* than trees. Earthkeeper 3(6): 22-25, 5 figures.

McAllister, Don E., *Editor and partial author.* 1993. Sea Wind, Bulletin of Ocean Voice International, Ottawa 7(3): 1-36, 17 figures.

McAllister, Don E. 1993. Review of: Indian Ocean tropical fish guide *by* Helmut Debelius. Sea Wind, Bulletin of Ocean Voice International, Ottawa 7(3): 32-33.

McAllister, Don E. 1993. Review of: Global marine biological diversity *edited by Elliot A. Norse.* Sea Wind, Bulletin of Ocean Voice International, Ottawa 7(3): 34-35.

McAllister, Don E., *Editor and partial author/Editeur et auteur en partie.* 1993. Global biodiversity, Ottawa 3(3): 1-46, numerous text figures; La biodiversité mondiale, Ottawa, 3(3): 1-46, schémas dans le texte plusieurs.

McAllister, Don E., and **Jane Topping**, 1993. A two-billion-dollar flood prevention plan. Global biodiversity, Ottawa 3(3): 21-28, 5 figures. L'harmonisation des cycles hydrologiques: un plan de 2 milliards $ pour prévenir les inondations; La biodiversité mondiale, Ottawa 3(3): 21-28, 5 figures.

McAllister, Don E. 1993. Slippery fish and boat efficiency. Global biodiversity, Ottawa 3(3): 29, 1 figure; Du poisson glissant à des bateaux efficaces. La biodiversité mondiale, Ottawa 3(3): 29, 1 figure.

McAllister, Don E. 1993. Review of: Re-Introduction News by IUCN Species Survival Commission. Global biodiversity, Ottawa,3(3): 36. La biodiversité mondiale, Ottawa 3(3): 36.

McAllister, Don E. 1993. Review of: Is the extinction crisis real? *by* Paul Ehrlich. Global biodiversity, Ottawa 3(3): 41; La biodiversité mondiale, Ottawa 3(3): 40-41.

McAllister, Don E. 1993. Review of: The keystone-species concept in ecology and conservation *by* L. S. Mills, M. S. Soulé, and D. F. Doak. Global biodiversity, Ottawa 3(3): 41-42; La biodiversité mondiale, Ottawa 3(3): 41.

McAllister, Don E., and **Alejandro Ansula.** 1993. Save our coral reefs. Pagyamanin ang mga bahura. A coral reef care manual. Ocean Voice International, Ottawa. xv + 126 pages, 99 figures and plates, 1 map.

McAllister, Don E. 1993. Pagyamanin ang mga bahura. Isang manwal ukol sa mga bahura sa Pilipinas at mga kalapit na dagat. Ocean Voice International, Ottawa. viii + 89 pages, 85 figures, 1 map.

McAllister, Don E. 1993. The eco-taxa hotspot approach to the conservation of biodiversity: Evolving tools. Association of Systematic Collections Newsletter 21(4): 47-48.

McAllister, Don E., *Editor and partial author.* 1993. Sea Wind, Bulletin of Ocean Voice International, Ottawa 7(4): 1-32, 11 figures.

McAllister, Don E. 1993. Biodiversity of the ocean depths and its value. Sea Wind, Bulletin of Ocean Voice International, Ottawa 7(4): 13-19.

McAllister, Don E. 1993. Alternative livelihoods for Atlantic coast fishers. 2. More options for diversifications. Sea Wind, Bulletin of Ocean Voice International, Ottawa 7(4): 22.

McAllister, Don E. 1993. Review of; More than a living: Fishing and the social order on a Polynesian atoll *by* Michael D. Lieber. Sea Wind, Bulletin of Ocean Voice International, Ottawa 7(4): 26-27.

McAllister, Don E., *Editor and partial author/Editeur et auteur en partie.* 1994. Global biodiversity, Ottawa 3(4): 1-48, numerous text figures; La biodiversité mondiale, Ottawa 3(4): 1-48, schémas dans le texte plusieurs.

McAllister, Don E. 1994. Review of: Issues. Global biodiversity, Ottawa 3(4): 42. La biodiversité mondiale, Ottawa, 3(4): 42.

McAllister, Don E. 1994. Review of: Cognition. Quarterly voice of Canadian Organic Growers, Ottawa. Global biodiversity, Ottawa 3(4): 44. Revue de Cognition. Publication trimestrielle de la Canadian Organic Growers, Ottawa. La biodiversité mondiale, Ottawa 3(4): 4.

McAllister, Don E. 1994. Review of: A comparison of ungrazed and livestock-grazed rock vegetations in Curaçao *by* Adolpho O. Debro and John A. de Freitas. Global biodiversity, Ottawa,3(4): 44-45; La biodiversité mondiale, Ottawa 3(4): 44-45.

McAllister, Don E. 1994. Review of: Global marine biological diversity *edited by* Elliott A. Norse. Global biodiversity, Ottawa 3(4): 46-47; La biodiversité mondiale, Ottawa (4): 46-47.

McAllister, Don E. *Editor and partial author.* 1994. Sea Wind, Bulletin of Ocean Voice International, Ottawa 8(1): 1-36, 12 figures.

McAllister, Don E. and **Patricia Almada-Villela**, 1994. Coral Reef Fish Specialist Group Report. Sea Wind, Bulletin of Ocean Voice International, Ottawa 8(1): 2-6, 1 figure.

McAllister, Don E. 1994. Review of: Marine Forum. The Quarterly Bulletin of the Canadian Marine Environmental Protection Society. Sea Wind, Bulletin of Ocean Voice International, Ottawa 8(1): 30-31.

McAllister, Don E. 1994. Review of: International Directory of Aquarist Organizations *by* Rob Huntley and Jaré Sausaman. Sea Wind, Bulletin of Ocean Voice International, Ottawa 8(1): 31-32.

McAllister, Don E., *Editor and partial author/Editeur et auteur en partie.* 1994. Global biodiversity, Ottawa 4(1): 1-48, numerous text figures; La biodiversité mondiale, Ottawa 4(1):1-48, schémas dans le texte plusieurs.

McAllister, Don E. 1994. Review of: Tales of a shaman's apprentice. An ethnobotanist searches for new medicines in the Amazon rain forest *by* Mark J. Plotkin. Global biodiversity, Ottawa 4(1): 39-40; La biodiversité mondiale, Ottawa 4(1): 39-40.

McAllister, Don E. 1994. Review of: Kill the cowboy. A battle of mythology in the new west *by* Sharman Apt Russell. Global biodiversity, Ottawa 4(1): 45-46; La biodiversité mondiale, Ottawa 4(1): 46.

McAllister, Don E. 1994. Review of: The range *by* Sherm Ewing. Global biodiversity, Ottawa 4(1): 46; La biodiversité mondiale, Ottawa 4(1): 46-47.

McAllister, Don E., *Editor and partial author.* 1994. Sea Wind, Bulletin of Ocean Voice International, Ottawa 8(2): 1-36, 12 figures.

McAllister, Don E. 1994. Possible causes of the collapse of the Atlantic groundfish fishery: Hypotheses to test, impacts to quanify (*sic*). Sea Wind, Bulletin of Ocean Voice International, Ottawa 8(2): 2-9, 2 figures.

McAllister, Don E., *Editor and partial author/Editeur et auteur en partie*. 1994. Global biodiversity, Ottawa 4(2): 1-48, numerous text figures; La biodiversité mondiale, Ottawa 4(2): 1-48, schémas dans le texte plusieurs.

McAllister, Don E. 1994. Tools for conserving biodiversity: inventories, biosystematics, museums, TAP, RAP, GAP, ETAP, and ATI. A species at a time is too slow! Global biodiversity, Ottawa 4(2): 16-21, 4 figures: Des outils pour la conservation de la biodiversité: inventaires, recherche biosystématique, musées, évaluation taxinomique, évaluation rapide, analyse des écarts, analyse des points chauds écotaxinomiques, inventaire intégral des taxons. L'approche monospécifique: trop lente! La biodiversité mondiale, Ottawa 4(2): 16-21, 4 figures.

McAllister, Don E. 1994. Preserving wood and biodiversity. Global biodiversity, Ottawa 4(2): 22-23, 1 figure; Préserver le bois et la biodiversité. La biodiversité mondiale, Ottawa 4(2): 22-23, 1 figure.

McAllister, Don E. 1994. Review of: Evaluating the carbon sequestration benefits of forestry projects in developing countries *by* Paul Faeth, Cheryl Cort and Robert Livernash. Global biodiversity, Ottawa 4(2): 43; La biodiversité mondiale, Ottawa 4(2): 43.

McAllister, Don E., *Editor and partial author*. 1994. Sea Wind, Bulletin of Ocean Voice International, Ottawa 8(3): 1-36, 12 figures.

McAllister, Don E., and **Jaime Baquero.** 1994. Ornamental fish industry's environmental program. Sea Wind, Bulletin of Ocean Voice International, Ottawa 8(3): 16-18.

McAllister, Don E. 1994. Alternative livelihoods for coastal fishers. 4. Building models of traditional fishing craft. Sea Wind, Bulletin of Ocean Voice International, Ottawa 8(3): 18-24, 3 figures.

McAllister, Don E. 1994. Review of: Life in a fishbowl. Confessions of an aquarium director *by* Murray Newman. Sea Wind, Bulletin of Ocean Voice International, Ottawa 8(3): 31-32.

McAllister, Don E., *Editor and partial author/Editeur et auteur en partie*. 1994. Global biodiversity, Ottawa 4(3): 1-48, numerous text figures; La biodiversité mondiale, Ottawa 4(3):1-48, schémas dans le texte plusieurs.

McAllister, Don E. 1994. Review of: Cordillera. A Journal of British Columbia Natural History. Global biodiversity, Ottawa 4(3): 39-40; Revue de: Cordillera. Journal de l'histoire naturelle de la Colombie-Britannique. La biodiversité mondiale, Ottawa 4(3): 39-40.

Alfonso, Noel, and **Don E. McAllister.** 1994. Biodiversity and the Great Whale Hydroelectric Project. Great Whale Public Review Support Office, Montréal, Great Whale Environmental Assessment: Background Paper 11: vii + 75 pages.

McAllister, Don E., Frederick W., Schueler, Callum Roberts, and **Julie P. Hawkins.** 1994. Mapping and GIS analysis of the global distribution of coral reef fishes on an equal-area grid, pages 155-175 *in* Mapping the diversity of nature. *Edited by* Ronald I. Miller. Chapman & Hall, London. xvii + 218 pages.

#**McAllister, Don E.** 1994. Why is biodiversity being lost? Incentives for protecting North American Biodiversity. Different Drummer 1(3): 32-34.

McAllister, Don E., and **Gary Spiller.** 1994. Trawling and dredging impacts on fish habitat and bycatch *in* Coastal Zone Canada '94, Cooperation in the Coastal Zone: Conference Proceedings, September 20-23, 1994. *Edited by* Peter G. Well and Peter J. Ricketts. World Trade and Convention Centre, Halifax, Nova Scotia, Canada 4: 1709-1718.

Alfonso, Noel, et **Don E. McAllister.** 1994. La biodiversité et le projet hydroélectrique Grande-Baleine. Dossier-synthèse Number. 11, Évaluation environnementale du projet Grande-Baleine, Bureau de soutien de l'examen public du projet Grande-Baleine, Montréal. vii + 81 pages.

McAllister, Don E., *Editor and partial author*. 1994. Sea Wind, Bulletin of Ocean Voice International, Ottawa 8(4): 1-32, 11 figures.

McAllister, Don E. 1994. Review of: Samudra Report *published by* Sebastian Mathew. Sea Wind, Bulletin of Ocean Voice International, Ottawa 8(4): 29-30.

#**McAllister, Don E.** 1995. Chapter 23. Marine biosystematic/biodiversity priorities: A Canadian perspective, pages 385-393 *in* Marine and coastal biodiversity in the Tropical Island Pacific Region. Volume 1. Species Systematics and Information Management Priorities. *Edited by* J. Maragos, M. Peterson, L. Eldridge, J. Bardach, and H. Takeuchi. Program on Environment, East-West Center, Honolulu, Hawaii. 424 pages.

McAllister, Don E., *Editor and partial author/Editeur et auteur en partie*. 1995. Global biodiversity, Ottawa 4(4): 1-48, numerous text figures; La biodiversité mondiale, Ottawa 4(4):1-48, schémas dans le texte plusieurs.

McAllister, Don E. 1995. Marine biodiversity workshop on systematics and databases of tropical Pacific Islands. Global biodiversity, Ottawa 4(4): 25-30, 12 figures; Atelier de travail sur la systématique et les bases de données sur la biodiversité des îles tropicales. La biodiversité mondiale, Ottawa 4(4): 25-30, 12 figures.

McAllister, Don E. 1995. Review of: International Forum: biodiversity, science & development held by IUBS held in Paris. Global biodiversity, Ottawa 4(4): 32-33; Le forum international sur la biodiversité, les sciences et le développement. La biodiversité mondiale, Ottawa 4(4): 32-33.

McAllister, Don E., *Editor and partial author*. 1995. Sea Wind, Bulletin of Ocean Voice International, Ottawa 9(1): 1-36, 12 figures.

McAllister, Don E., *Editor and partial author/Editeur et auteur en partie*. 1995. Global biodiversity, Ottawa 5(1): 1-48, numerous text figures; La biodiversité mondiale, Ottawa 5(1):1-48, schémas dans le texte plusieurs.

McAllister, Don E., *Editor and partial author*. 1995. Sea Wind, Bulletin of Ocean Voice International, Ottawa 9(2): 1-40, 12 figures.

McAllister, Don E., *Editor and partial author/Editeur et auteur en partie*. 1995. Global biodiversity, Ottawa 5(2): 1-48, numerous text figures; La biodiversité mondiale, Ottawa 5(2): 1-48, schémas dans le texte plusieurs.

McAllister, Don E. 1995. Consequences of transgressing human laws and nature's laws. Global biodiversity, Ottawa et de la nature. La biodiversité mondiale, Ottawa 5(2):16.

McAllister, Don E. 1995. How will climate change affect taiga underlain by permafrost? Global biodiversity, Ottawa 5(2): 33; Les incidences du changement climatique sur la taïga. La biodiversité mondiale, Ottawa 5(2): 32.

McAllister, Don E., *Editor and partial author*. 1995. Sea Wind, Bulletin of Ocean Voice International, Ottawa 9(3): 1-36, 8 figures.

McAllister, Don E. 1995. Offshore and deep-sea marine reserves and parks: A major gap in Protected Area Networks. Sea Wind, Bulletin of Ocean Voice International, Ottawa 9(3): 4-14, 2 figures, 2 tables.

McAllister, Don E. 1995. Advisory body to Biodiversity Convention meets in Paris. Sea Wind, Bulletin of Ocean Voice International, Ottawa 9(3): 18-23.

McAllister, Don E., *Editor and partial author/Editeur et auteur en partie.* 1995. Global biodiversity, Ottawa 5(3): 1-48, numerous text figures; La biodiversité mondiale, Ottawa 5(3): 1-48, schémas dans le texte plusieurs.

McAllister, Don E. 1995. Review of: IUCN Red List categories *by* IUCN Species Survival Commission, Gland. Global biodiversity, Ottawa, 5(3): 41-42; La biodiversité mondiale, Ottawa 5(3): 41-42.

McAllister, Don E. 1995. Review of: Good dirt – confessions of a conservationist *by* David E. Morine. Global biodiversity, Ottawa 5(3): 46; La biodiversité mondiale, Ottawa 5(3): 46.

McAllister, Don E. 1995. The Green School Biodiversity Booklet/Livret sur la Biodiversité pour les Écoles "Vertes". Ocean Voice International, Ottawa. 12 pages, 4 figures.

McAllister, Don E. 1995. First meeting of Advisory Body to the Convention on Biological Diversity: Success in Paris. Global biodiversity, Ottawa 5(3): 19-21; 1 figure. Première réunion fructueuse, à Paris, du conseil consultatif à la Convention sur la diversité biologique. La biodiversité mondiale, Ottawa 5(3): 19-21, 2 figures.

McAllister, Don E. 1995. Review of: Birds to watch 2: The world list of threatened birds. Global biodiversity, Ottawa 5(3): 42; La biodiversité mondiale, Ottawa 5(3): 42.

McAllister, Don E. 1995. Review of: Aerobiologia. Global biodiversity, Ottawa 5(3): 46; La biodiversité mondiale, Ottawa 5(3): 46.

Mosquin, Ted, Peter G. Whiting, and **Don E. McAllister.** 1995. Canada's biodiversity: the variety of life, its status, economic benefits, conservation costs and unmet needs. Canadian Museum of Nature, Ottawa and Henderson Book Series 23: xxiv + 293 pages, 61 figures [La biodiversité du Canada: État actuel, avantages économiques, coûts de conservation et besoins non satisfaits (disquette)].

McAllister, Don E. 1995. Status of the World Ocean and its Biodiversity. Sea Wind, Bulletin of Ocean Voice International, Ottawa 9(4): 1-72, 7 figures.

McAllister, Don E., *Editor and partial author/Editeur et auteur en partie.* 1996. Global biodiversity, Ottawa 5(4): 1-48, numerous text figures. La biodiversité mondiale, Ottawa 5(4): 1-48, schémas dans le texte plusieurs.

McAllister, Don E. 1996. Review of: Watershed sentinel. Environmental News from Georgia Strait and the Islands. Global biodiversity, Ottawa 5(4): 47; La biodiversité mondiale, Ottawa 5(4): 45.

McAllister, Don E., *Editor and partial author.* 1996. Sea Wind, Bulletin of Ocean Voice International, Ottawa 10(1): 1-31, 6 figures.

Almada-Villela, Patricia, and **Don E. McAllister.** 1996. IUCN SSC Coral Reef Fish Specialist Group. Sea Wind, Bulletin of Ocean Voice International, Ottawa 10(1): 13-14.

McAllister, Don E., *Editor and partial author/Editeur et auteur en partie.* 1996. Global biodiversity, Ottawa 6(1): 1-48, numerous text figures; La biodiversité mondiale, Ottawa 6(1): 1-48, schémas dans le texte plusieurs.

McAllister, Don E. 1996. Review of: Biodiversity news. The Smithsonian MAB Program *by* Smithsonian Institution, Washington. Global biodiversity, Ottawa 6(1): 46; Revue de: Biodiversity news. The Smithsonian MAB Program *par* Smithsonian Institution, Washington. La biodiversité mondiale, Ottawa 6(1): 46.

McAllister, Don E., *Editor and partial author.* 1996. Sea Wind, Bulletin of Ocean Voice International, Ottawa 10(2): 1-36, 14 figures.

McAllister, Don E. 1996. Letter to the Editor [About F. Earl Kennedy]. Sea Wind, Bulletin of Ocean Voice International, Ottawa 10(2): 3-4.

McAllister, Don E. 1996. 8th International Coral Reef Symposium in Panama. Sea Wind, Bulletin of Ocean Voice International, Ottawa 10(2): 18-20, 1 figure.

#**McAllister, Don E.** 1996. Promoting the future of the marine ornamental industry and coral reefs. OFI (Ornamental Fish International) Journal 16: 16-19.

de Fontaubert, Charlotte, and **Don McAllister.** 1996. Addressing marine and coastal biodiversity through the CBD process: the "Jakarta Mandate" and beyond. Biodiversity Bulletin, August 1996: 3-5 (www.bionet-us.org/docs/bb2.pdf).

McAllister, Don E., *Editor and partial author.* 1996. Sea Wind, Bulletin of Ocean Voice International, Ottawa 10(3): 1-36, 9 figures.

McAllister, Don E. 1996. Review of: IMCRA – An ecosystem based hierarchial classification system for Australia's coastal and marine environments *by* R. Thackway and I. D. Cresswell. Sea Wind, Bulletin of Ocean Voice International, Ottawa 10(3): 33-34.

McAllister, Don E. 1996. Review of: Beyond Noah's Ark: The evolving role of modern zoological parks and aquariums in field conservation *by* Michael Hutchins and William G. Conway. Sea Wind, Bulletin of Ocean Voice International, Ottawa 10(3): 35.

McAllister, Don E., *Editor and partial author/Editeur et auteur en partie.* 1996. Global biodiversity, Ottawa 6(2): 1-48, numerous text figures; La biodiversité mondiale, Ottawa 6(2): 1-48, schémas dans le texte plusieurs.

Schueler, F. W., Julie Hawkins, Callum Roberts, and **Don E. McAllister.** 1996. Databases and analysis of geographic ranges of coral reef fishes: Virtues of points, grids and polygons. Paper presented at the 8th International Coral Reef Symposium, 24-29 June 1996, Panama City, Panama.

#**McAllister, Don E.** 1996. Cyanide collecting: No "quick fixes". OFI (Ornamental Fish International) Journal 17: 10-11.

McAllister, Don E. *Editor and partial author/Editeur et auteur en partie.* 1996. Global biodiversity, Ottawa 6(3): 1-48, numerous text figures. La biodiversité mondiale, Ottawa 6(3): 1-48, schémas dans le texte plusieurs.

McAllister, Don E,. 1996. Eco-Products: Eco-foam, duplex printers, and energy efficient computers. Global biodiversity, Ottawa 6(3): 19-20, 2 figures; Mousse écologique, imprimantes duplex, et ordinateurs écoénergétiques; La biodiversité mondiale, Ottawa 6(3): 19-20, 2 figures.

McAllister, Don E. 1996. Report on International Coral Reef Symposium, Panama City, 24-29 June 1996. Global biodiversity, Ottawa 6(3) 5-26; Rapport sur Symposium international sur les Récifs coralliens, 24-29 juin 1996, Panama City, Panama. La biodiversité mondiale, Ottawa 6(3): 5-26.

McAllister, Don E. 1996. Session 2. Ecosystem Management of Fisheries. Introduction. Presentation at the Fourth Session of the Global Biodiversity Forum International: Montreal, August 31-September 1, 1996.

McAllister, Don E., *Editor and partial author.* 1996. Sea Wind, Bulletin of Ocean Voice International, Ottawa 10(4): 1-36, 19 figures.

#**McAllister, Don E.** 1996. Pagyamanin Ang Mga Bahura. Isang manwal ukol sa mga bahura sa Pilipinas at mga kalapit na dagat. Ocean Voice International, Ottawa and Haribon Foundation for Conservation of Natural Resources, Manila. 89 pages, 88 figures (Tagalog edition of Save Our Coral Reefs).

#**McAllister, Don E.** 1996. Atong Panalipdan Ang Gasangan. Ocean Voice International, Ottawa and Haribon Foundation for Conservation of Natural Resources, Manila. 106 pages, 88 figures (Visayan edition of Save Our Coral Reefs).

McAllister, Don E,. *Editor and partial author/Editeur et auteur en partie*. 1997. Global biodiversity, Ottawa 6(4): 1-48, numerous text figures; La biodiversité mondiale, Ottawa 6(4): 1-48, schémas dans le texte plusieurs.

McAllister, Don E., *Editor and partial author/Editeur et auteur en partie*. 1997. Global biodiversity, Ottawa 7(1): 1-48, numerous text figures; La biodiversité mondiale, Ottawa 7(1): 1-48, schémas dans le texte plusieurs.

McAllister, Don E. 1997. The looming threat to the fair sharing of benefits: What can be done to stop it? Global biodiversity, Ottawa 7(1): 32-33; Émergence d'une menace au juste partage des avantages: comment l'enrayer. La biodiversité mondiale, Ottawa 7(1): 32-33.

McAllister, Don E., *Editor and partial author*). 1997. Sea Wind, Bulletin of Ocean Voice International, Ottawa 11(1): 1-52, 3 figures.

McAllister, Don E. 1997. Table of Contents for SEA WIND. Volumes 6 to 10, 1992-1996. Sea Wind, Bulletin of Ocean Voice International, Ottawa 11(1): 10-51.

McAllister, Don E., *Editor and partial author/Editeur et auteur en partie*. 1997. Global biodiversity, Ottawa 7(2): 1-64, numerous text figures; La biodiversité mondiale, Ottawa 7(2): 1-64, schémas dans le texte plusieurs.

McAllister, Don E., *Editor and partial author*. 1997. Sea Wind, Bulletin of Ocean Voice International, Ottawa 11(2): 1-36, 8 figures.

McAllister, Don E. 1997. Review of: Ocean Forests: The diversity and value of kelp forest ecosystems *by* Carrie Konig. Sea Wind, Bulletin of Ocean Voice International, Ottawa 11(2): 36.

Holthus, Paul, Don McAllister, and **Patricia Almada-Villela.** 1997. International Year of the Reef. Species, Newsletter of the Species Survival Commission 28: 3 pages, 1 figure (www.iucn.org/themes/ssc/species/spec28/features/iyor.htm).

McAllister, Don. 1997. MAI: Global power swing to transnationals? Japan Environmental Monitor, 91: unpaginated (June-July)

McAllister, Don E., Andrew L. Hamilton, and **Brian Harvey.** 1997. Global Freshwater Biodiversity: Striving for the integrity of freshwater ecosystems. Sea Wind, Bulletin of Ocean Voice International, Ottawa 11(3): 1-140, 21 figures.

McAllister, Don E., *Editor and partial author/Editeur et auteur en partie*. 1997. Global biodiversity, Ottawa 7(3): 1-48, numerous text figures; La biodiversité mondiale, Ottawa 7(3): 1-48, schémas dans le texte plusieurs.

McAllister, Don E., *Editor and partial author*. 1997. Sea Wind, Bulletin of Ocean Voice International, Ottawa 11(4): 1-36, 8 figures.

McAllister, Don E., *Editor and partial author/Editeur et auteur en partie)*. 1998. Global biodiversity, Ottawa 7(4): 1-48, numerous text figures; La biodiversité mondiale, Ottawa 7(4): 1-48, schémas dans le texte plusieurs.

McAllister, Don E., Andrew L. Hamilton, and **Brian Harvey.** 1998. Gaps in freshwater ecosystem research. Global biodiversity, Ottawa, 7(4): 12-17, 3 figures: Les lacunes dans la recherche sur les écosystèmes d'eau douce. La biodiversité mondiale, Ottawa 7(4): 12-17, 2 figures.

McAllister, Don E., *Editor and partial author*. 1998. Sea Wind, Bulletin of Ocean Voice International, Ottawa 12(1): 1-48, 8 figures.

Risk, Michael J., Don E. McAllister, and **Linda Behnken,** 1998. Conservation of cold- and warm-water seafans: Threatened ancient gorgonian groves. Sea Wind, Bulletin of Ocean Voice International, Ottawa 12(1): 2-21, 4 figures.

Martel, André, and **Don E. McAllister.** 1998. Mixing mussels: Is introduction a threat to the native Pacific coast blue mussel? Sea Wind, Bulletin of Ocean Voice International, Ottawa 12(1): 26-28, 1 figure.

McAllister, Don E. 1998. Review of: Distribution and status of deep sea corals off Nova Scotia *by* Heather Breeze. Sea Wind, Bulletin of Ocean Voice International, Ottawa 12(1): 5-46.

McAllister, Don E., *Editor and partial author/Editeur et auteur en partie*. 1998. Global biodiversity, Ottawa 8(1): 1-32, numerous text figures; La biodiversité mondiale, Ottawa 8(1): 1-32, schémas dans le texte plusieurs.

#**McAllister, Don E.** 1998. Status of the world's fresh waters and fishes. A Symposium Honouring Dr. E. J. Crossman. 78th Annual Meeting of the American Society of Ichthyologists and Herpetologists, July 16-July 22, 1998, University of Guelph, Guelph, Ontario. [abstract].

McAllister, Don E., *Editor and partial author*. 1998. Sea Wind, Bulletin of Ocean Voice International, Ottawa 12(2): 1-40, 11 figures.

McAllister, Don E., Labbish Ning Chao, and **C.-T. Shih.** 1998. Cyanide fisheries: Where did they start? Sea Wind, Bulletin of Ocean Voice International, Ottawa 12(2): 2-8, 2 figures.

McAllister, Don E. 1998. Oil slicks: A threat to eggs, embryos and larvae of marine fishes and to fisheries? Sea Wind, Bulletin of Ocean Voice International, Ottawa 12(2): 27-31, 2 figures.

McAllister, Don E. 1998. Review of: Reefs at Risk. A map-based indicator of threats to the world's coral reefs *by* Dirk Bryant. Sea Wind, Bulletin of Ocean Voice International, Ottawa 12(2): 38.

McAllister, Don E., *Editor and partial author/Editeur et auteur en partie*. 1998. Global biodiversity, Ottawa 8(2): 1-40, numerous text figures; La biodiversité mondiale, Ottawa 8(2): 1-40, schémas dans le texte plusieurs.

McAllister, Don E. 1998. The lamp shells *Phylum Brachiopoda*. Global biodiversity, Ottawa 8(2): 14, 1 figure. Les térébratules *Phylum Brachiopoda*. La biodiversité mondiale, Ottawa 8(2): 14, 1 figure.

McAllister, Don E. 1998. A working bibliography on the toxic effects of cyanide on fishes and corals. Ocean Voice International, Ottawa. 27 pages.

McAllister, Don E. 1998. Status of biodiversity in the planet's fresh and marine waters: The crisis in aquatic biodiversity. Paper presented at ACP-EU Fisheries Research Initiative on Sustainable Use of Aquatic Biodiversity: Data, Tools and Cooperation, EXPO'98, IPIMAR, Lisbon, Portugal, 3-5 September 1998. 5 pages.

McAllister, Don E., *Editor and partial author*. 1998. Sea Wind, Bulletin of Ocean Voice International, Ottawa 12(3): 1-36, 11 figures.

McAllister, Don E. 1998. Jubilee 2000 – celebrating the Second Millennium by cancelling debts to the world's poorest – Y2K-JB. Sea Wind, Bulletin of Ocean Voice International, Ottawa 12(3): 11-15, 2 figures.

McAllister, Don E. 1998. Review of: Red Sea Reef Guide *by* Helmut Debelius. Sea Wind, Bulletin of Ocean Voice International, Ottawa, 12(3): 31-32.

McAllister, Don E. 1998. Review of: Sea cucumbers of British Columbia, southeast Alaska and Puget Sound *by* Philip Lambert. Sea Wind, Bulletin of Ocean Voice International, Ottawa 12(3): 32-33.

McAllister, Don E. 1998. Review of: Tropical Reef Life *by* A. W. Michael. Sea Wind, Bulletin of Ocean Voice International, Ottawa 12(3): 33.

McAllister, Don E. 1998. Review of: Murky waters: Environmental effects of aquaculture in the US *by* Rebecca Goldburg and Tracy Triplett. Sea Wind, Bulletin of Ocean Voice International, Ottawa 12(3): 33-34.

McAllister, Don E. 1998. Water: The essence of life or a silent threat. The implication of discharge of toxic substances into marine and freshwater environments. Paper presented to the Society of Environmental Toxicology and Chemistry (SETAC), Laurentian Chapter, Ontario, 20 May 1998 (www. atw.ca).

McAllister, Don E., *Editor and partial author/Editeur et auteur en partie*. 1998. Global biodiversity, Ottawa 8(3): 1-32, numerous text figures; La biodiversité mondiale, Ottawa 8(3): 1-32, schémas dans le texte plusieurs.

McAllister, Don E. 1998. The crises in marine biodiversity and key knowledge. Presentation given at a panel in Pacem in Maribus XXVI [Peace in the Seas], a conference held November 29th to December 3rd, in Halifax, Nova Scotia. 26 pages (www.cacor.ca/mcall.html).

Roberts, Callum M., Julie P. Hawkins, Don E. McAllister, and **Frederick W. Schueler.** 1998. Distribution and conservation of coral reef fish diversity. Paper presented at the International Society for Reef Studies, France. 5 pages.

McAllister, Don E., *Editor and partial author*. 1998. Sea Wind, Bulletin of Ocean Voice International, Ottawa 12(4): 1-44, 13 figures.

McAllister, Don E. 1998. Bill Reid: Haida carver, sculptor, jeweller, poet and writer, 1920-1998. Sea Wind, Bulletin of Ocean Voice International, Ottawa 12(4): 7-8.

#**Roberts, Callum M., Julie Hawkins, Alan E. Strong, Frederick W. Schueler,** and **Don E. McAllister.** 1998. The distribution of coral reef fish biodiversity: the climate-biodiversity connection. Paper presented at the Fourth Meeting of the Conference of the Parties to the UN Framework Convention on Climate Change held 2nd-13th November 1998, Buenos Aires, Argentina.

#**Roberts, Callum M., Julie Hawkins, Alan E. Strong, Frederick W. Schueler,** and **Don E. McAllister.** 1998. The distribution of coral reef fish biodiversity: the climate-biodiversity connection. Sea Wind, Bulletin of Ocean Voice International, Ottawa 12(4): 14-28, 8 figures.

McAllister, Don. 1998. Opinion: Trawls are strip-mining the oceans. Environment New Services, 23 December 1998, 3 pages, 2 figures (http://ens.lycos.com/ens/dec98/1998L-12-23-03.html).

McAllister, Don E., *Editor and partial author/Editeur et auteur en partie*. 1999. Global biodiversity, Ottawa 8(4): 1-32, numerous text figures; La biodiversité mondiale, Ottawa 8(4): 1-32, schémas dans le texte plusieurs.

McAllister, Don E., *Editor and partial author*. 1999. Sea Wind, Bulletin of Ocean Voice International, Ottawa 13(1): 1-40, 6 figures.

McAllister, Don E. 1999. Review of: The Ecology of the Indonesian Seas *by* Tomas Tomascik, Anmarie Janice Mah, Anugerah Wontji and Mohammad Kasim Moosa. Sea Wind, Bulletin of Ocean Voice International, Ottawa 13(1): 38-39.

McAllister, Don E. 1999. Review of: The Ecology of the Indonesian Seas *by* Tomas Tomascik, Anmarie Janice Mah, Anugerah Wontji and Mohammad Kasim Moosa. ISBN 962-593-078-7 Volume VII 642 pages. and ISBN 962-593-163-5 Volume VIII 746 pages. The Ecology of Indonesia Series. Garuda Indonesia, Periplus Editions (HK) Ltd, 1997. Reef Encounters 25: 41-42.

McAllister, Don E., J. Baquero, G. Spiller, and **R. R. Campbell.** 1999. A global trawling ground survey. Report prepared for the Marine Biological Conservation Institute, World Resources Institute and Ocean Voice International, Ottawa. 37 pages.

McAllister, Don E., John Craig, Nick Davidson, and **Mary Seddon.** 1999. Large dam impacts on freshwater biodiversity. Report prepared for the IUCN – The World Conservation Union as a contribution to the work of the World Commission on Dams, Ottawa. 131 pages, 11 figures, 20 tables.

McAllister, Don E., *Editor and partial author*. 1999. Sea Wind, Bulletin of Ocean Voice International, Ottawa 13(2): 1-36, 6 figures.

McAllister, Don E. 1999. The orange roughy (*Hoplostethus atlanticus*), tasty, deep-dwelling and long-lived fish: At risk? Sea Wind, Bulletin of Ocean Voice International, Ottawa 13(2): 2-6, 2 figures.

McAllister, Don E. 1999. The magnificent frigatebird. Sea Wind, Bulletin of Ocean Voice International, Ottawa 13(2): 7, 1 figure.

McAllister, Don E., and **Katja Rodriguez.** 1999. The Green School Coral Reef Booklet. Ocean Voice International, Ottawa 16 pages, 13 figures.

McAllister, Don E., Ning Labbish Caho (*sic*), and **C.-T. Shih,** 1999. Cyanide fisheries: Where did they start? The Secretariat of the Pacific Community Coastal Fisheries Programme, Numea, New Caledonia, Live Reef Fish Information Bulletin, 5 (March 1999): 8 pages. (www.spc.org.nc/coastfish/News/lrf/5/Lt. RF5.htm).

McAllister, Don E. 1999. Is mariculture the remedy to problems of coral reefs of coastal communities? The Secretariat of the Pacific Community Coastal Fisheries Programme, Numea, New Caledonia, Live Reef Fish Information Bulletin, 5 (March 1999): 4 pages. (www.spc.org.nc/coastfish/News/lrf/5/9Maricu.htm).

#**McAllister, Don E.** 1999. Crisis in marine biodiversity and key knowledge. CACOR (The Canadian Association for the Club of Rome) Proceedings 2(1): 14-27.

McAllister, Don E., (*Editor and partial author*). 1999. Sea Wind, Bulletin of Ocean Voice International, Ottawa, 13(3): 1-40, 5 figures.

McAllister, Don E,. 1999. Eco-labelling for small-scale fishers and consumers. Sea Wind, Bulletin of Ocean Voice International, Ottawa, 13(3): 2-9, 1 figure.

McAllister, Don E. 1999. Review of: Guide d'identification du phytoplancton marin de l'Estuaire et du Golfe du Saint-Laurent, incluant également certains protozoaires *by* Lyse Bérard-Therriault, Michel Poulin and Luci Bossé. Sea Wind, Bulletin of Ocean Voice International, Ottawa 13(3): 36-37.

McAllister, Don E. 1999. Review of: Indian Ocean Reef Guide *by* Helmut Debelius. Sea Wind, Bulletin of Ocean Voice International, Ottawa 13(3): 38.

McAllister, Don E. *Editor and partial author.* 1999. Sea Wind, Bulletin of Ocean Voice International, Ottawa 13(4): 1-36, 4 figures.

#**McAllister, Don E.** 2000. Canadian freshwater biodiversity. Essay 12, pages 83-85 in Freshwater ecoregions of North America. A conservation assessment. *Edited by* Robin A. Abell, David M. Olson, Eric Dinerstein, Patrick T. Hurley, James T. Diggs, William Eichbaum, Stephen Walters, Wesley Wettengel, Tom Allnutt, Colby J. Loucks, and Prashant Hedao. Island Press, Washington, D.C. and Covelo, California. 319 pages.

McAllister, Don E., *Editor and partial author.* 2000. Sea Wind, Bulletin of Ocean Voice International, Ottawa 14(1): 1-40, 11 figures.

McAllister, Don E. 2000. A hierarchical marine ecosystem classification completed for Canada's West Coast. Sea Wind, Bulletin of Ocean Voice International, Ottawa 14(1): 4-6, 2 figures.

McAllister, Don E. 2000. Review of: Ocean Yearbook 13 *by* Elisabeth Mann Borgese, Aldo Chirrop Chircop, Moira McConnell, and Joseph R. Morgan. Sea Wind, Bulletin of Ocean Voice International, Ottawa 14(1): 35-39.

McAllister, Don E., *Editor and partial author.* 2000. Biodiversity (Journal of Life on Earth) 1(1): 1-48 pages, numerous text figures.

McAllister, Don E. 2000. Options in agriculture. Biodiversity (Journal of Life on Earth) 1(1): 2-5, 1 figure, 2 tables.

McAllister, Don E. 2000. Biodiversity awareness: people, museums and the web. Biodiversity (Journal of Life on Earth) 1(1): 38-39.

McAllister, Don. 2000. In favour of farming diversity. Biodiversity (Journal of Life on Earth) 1(1): 40-41, 1 figure.

McAllister, Don E. 2000. Review of: Return to resistance. Breeding crops to reduce pesticide dependence *by* Raoul A. Robinson. Biodiversity (Journal of Life on Earth) 1(1): 42-43.

McAllister, Don E. 2000. Review of: People, plants and patents. The impact of intellectual property rights on trade, plant biodiversity, and rural society *by* the Crucible Group, Ottawa. Biodiversity (Journal of Life on Earth) 1(1): 43.

McAllister, Don, John Craig, Nick Davidson, Dianne Murray, and **Mary Seddon.** 2000. Biodiversity impacts of large dams. Prepared for Thematic Review II.1: Dams, ecosystem functions and environmental restoration. Contributing paper on behalf of IUCN – The World Conservation Union to the World Commission on Dams. iv + 61 pages., 6 figures, 20 tables (www.dams.org).

McAllister, Don E. 2000. A model framework for a marine ecosystem classification for Canada's West Coast. A discussion paper. Report by Ocean Voice International, Ottawa for Marine Conservation, Western Canada Service Centre, Parks Canada, Vancouver. 90 pages, numerous illustrations.

McAllister, Don E. 2000. Biodiversity in Canadian fresh and marine waters, page 81-105, 5 figures *in* Biodiversity in Canada: Ecology, ideas, and action. *Edited by* Stephen Bocking. Broadview Press, Peterborough. xxv + 426 pages.

McAllister, Don E., *Editor and partial author.* 2000. Sea Wind, Bulletin of Ocean Voice International, Ottawa 14(2): 1-36, 13 figures.

McAllister, Don E., and **Elisabeth Janssen.** 2000. Mounting seaweeds for fun or a livelihood. Sea Wind, Bulletin of Ocean Voice International, Ottawa 14(2): 19-24, 4 figures.

McAllister, Don E. 2000. Review of: Frederick Street. Life and death on Canada's Love Canal *by* Maude Barlow and Elizabeth May. Sea Wind, Bulletin of Ocean Voice International, Ottawa 14(2): 32-35.

McAllister, Don E., *Editor and partial author.* 2000. Biodiversity (Journal of Life on Earth) 1(2): 1-48 pages, numerous text figures.

McAllister, Don E. 2000. Pineapple, *Ananas comosus*. Biodiversity (Journal of Life on Earth) 1(2): 21, 1 figure.

McAllister, Don E. 2000. Review of: Ocean Yearbook 13 *Edited by* Elisabeth Mann Borgese, Aldo Chirrop Chircop Moira McConnell and Joseph R. Morgan. Biodiversity (Journal of Life on Earth) 1(2): 42-45, 1 figure.

Alfonso, N., and **Don E. McAllister.** 2000. The distribution of corals on Canada's West Coast. Paper presented in Session 4: Conservation at the 1st International Symposium on Deep Sea Corals: Science of Conservation of Deep Sea Corals, Halifax, Nova Scotia, July 29 to August 3, 2000. 1 page.

McAllister, Don E. *Editor and partial author.* 2000. Sea Wind, Bulletin of Ocean Voice International, Ottawa 14(3): 1-36, 10 figures.

McAllister, Don E. 2000. Environment and bulk water export under free trade. Sea Wind, Bulletin of Ocean Voice International, Ottawa 14(3): 16-21, 2 figures.

McAllister, Don E. 2000. Fisheries and civil governance. How should fisheries be managed in a democratic society? Sea Wind, Bulletin of Ocean Voice International, Ottawa 14(3): 22-23.

McAllister, Don E. 2000. Review of: Under Southern Seas. The Ecology of Australian Rocky Reefs *edited by* Neil Andrews. Sea Wind, Bulletin of Ocean Voice International, Ottawa 14(3): 33-34.

McCrae, Ellen, Elvira Maria Alvarado Chacón, Monica Abello, Jaime Baquero, and **Don McAllister.** 2000. Greater Caribbean Coral Reef Care Manual. Unpublished manuscript, Ocean Voice International, Ottawa and Siwa-Ban Foundation, Museo del Mar, Fundación Universidad Jorge Tadeo Lozano. 118 pages.

McAllister, Don E., *Editor and partial author.* 2000. Biodiversity (Journal of Life on Earth) 1(3): 1-48 pages, numerous text figures.

McAllister, Don E. 2000. Review of: The age of spiritual machines. When computers exceed human intelligence *by* Ray Kurzwill. Biodiversity (Journal of Life on Earth) 1(3): 42-43.

McAllister, Don E., *Editor and partial author.* 2000. Biodiversity (Journal of Life on Earth) 1(4): 1-48 pages, numerous text figures.

McAllister, Don E., *Compiler.* 2000. Contents & Index to Volume 1. Biodiversity (Journal of Life on Earth) 1(4): 47-48, endpaper.

McAllister, Don E., *Editor and partial author.* 2000. Sea Wind, Bulletin of Ocean Voice International, Ottawa 14(4): 1-40, 12 figures.

Burke, Lauretta, Yumiko Kura, Ken Kassem, Carmen Revenga, Mark Spalding, and **Don McAllister.** 2000. Pilot Analysis of Global Ecosystems (PAGE): Coastal Ecosystems. World Resources Institute, Washington. xii + 5 + 94 pages, 16 figures, 20 tables, 18 maps (www.wri.org/wr2000/coast_page.html) (ISBN 1-56973-458-5).

Coad, Brian W., James D. Reist, Claude B. Renaud, Don E. McAllister, Peter Rask Møller, Noel Alfonso, and **Fikret Berkes.** 2001. A Field Guide to the Arctic Marine Fishes of Canada. Poster presented at Arctic Ocean Sciences Board, Twentieth Meeting (AOSB-XX), 23-24 April 2001, Iqaluit.

McAllister, Don E., *Editor and partial author.* 2001. Biodiversity (Journal of Life on Earth) 2(1): 1-48 pages, numerous text figures.

McAllister, Don E. 2001. The copper redhorse, *Moxostoma hubbsi* a disappearing Canadian endemic. Biodiversity (Journal of Life on Earth) 2(1): 27-28, 2 figures.

McAllister, Don E., *Editor and partial author.* 2001. Biodiversity (Journal of Life on Earth) 2(2):1-48 pages, numerous text figures.

Coad, Brian W., James D. Reist, Claude B. Renaud, Don E. McAllister, Peter Rask Møller, Noel Alfonso, and **Fikret Berkes.** 2001. A Field Guide to the Arctic Marine Fishes of Canada. Poster presented at the Tenth European Congress of Ichthyology - ECI X, Prague, September 3-7, 2001.

Roberts, Callum M., Colin J. McClean, John E. N. Veron, Julie P. Hawkins, Gerald R. Allen, Don E. McAllister, Cristina G. Mittermeier, Frederick W. Schueler, Mark Spalding, Fred Wells, Carly Vynne, and **Timothy B. Werner.** 2002. Marine biodiversity hotspots and conservation priorities for tropical reefs. Science 295: 1280-1284.

Roberts, Callum M., Colin J. McClean, John E. N. Veron, Julie P. Hawkins, Gerald R. Allen, Don E. McAllister, Cristina G. Mittermeier, Frederick W. Schueler, Mark Spalding, Fred Wells, Carly Vynne, and **Timothy B. Werner.** 2002. Corrections and clarifications. Science 296: 1027-1028.

McAllister, Don E. 2002. Marine biodiversity of Canada: threats and conservation solutions. Biodiversity (Journal of Life on Earth) 3(1): 11-16, 5 figures *[excerpt from*: Stephen Bocking. 2000. Biodiversity in Canada. Ecology, ideas, and action. Broadview Press, Peterborough. xxv + 426 pages).

Coad, Brian W., and **Don E. McAllister.** 2002. Dictionary of Ichthyology. First posted 4 September 2002 at www.briancoad.com, maintained by Brian W. Coad and Nicholas P. Coad, Pure Throttle Technologies Inc., Ottawa, Ontario.

A Tribute to Patrick W. Colgan 1944-2004

IAN THOMPSON

Canadian Forest Service, 1219 Queen Street East, Sault Ste. Marie, Ontario P6A 5M7 Canada;
e-mail: Ian.Thompson@ NRCan-RNCan.gc.ca

Thompson, Ian. 2010. A tribute to Patrick W. Colgan 1944-2004. Canadian Field-Naturalist 124(4): 357–366.

Patrick Colgan and partner Marcia Sweet, at home in Burlington in 2001.

Patrick Colgan died on 21 July 2004 from the amyotrophic lateral sclerosis (ALS or Lou Gehrig's disease) that had been diagnosed at the end of April 2003. Patrick was married to Valerie Salmond from 1966 to 1986. They had two sons, Andrew and Jeffery. After a career teaching at Queen's University in Kingston, Patrick accepted an administrative position with the Canadian Museum of Nature and he and his partner, Martha Sweet, moved to Ottawa. At the time of his death, Patrick was the director of research programs for Royal Botanical Gardens (RBG), in Hamilton and Burlington, Ontario. RBG had accorded him emeritus status during the latter period of his illness, in 2004. He is sadly missed by Marcia and family.

Patrick earned an Honours BA (with a major in animal psychology) in 1967 from the University of Toronto and a Master's degree in psychology from Harvard University. After receiving his PhD from Cornell University in 1971, he accepted a position as assistant professor in the Biology Department at Queen's University. From 1979-80, he was the "Royal Society Suffield Scholar", at Sussex University, England. In 1984, he was promoted to Professor of Biology at Queen's University and served as Associate Head and Acting Head of the Department for several periods from 1987 through 1991. He also served as the Chair of Life Sciences, School of Graduate Studies from 1985-87. Patrick supervised 19 master's degree students, 7 doctoral dissertations, and 5 post-doctoral fellows, and served on the supervisory committees of more than 30 other graduate students.

Patrick was an expert in fish behaviour, focussing on aspects of motivation and proximate causation, and with his students, published many quantitative papers on the subject. Between 1975 and 1986, he wrote or co-edited four books on the quantitative study of animal behaviour. Patrick and his graduate students produced a remarkable number of publications, many of which continue to be cited (see following bibliography). He served as the editor of *Animal Behaviour* in 1982-1985, was President of the Animal Behaviour Society from 1989-90 and was elected a Fellow in 1991. Patrick was a voracious reader and he was in constant demand as a reviewer of books for journals and news-

papers because of the quality of his reviews. He was the book review editor for *Behavioural Processes* from 1993-1997 and for *Global Biodiversity* 1994-1997. As well, he was a frequent contributor of reviews to *The Canadian Field-Naturalist* in from 1981 to 2002 and the *Canadian Book Review Annual* from 1993 to 2004. He continued to do book reviews up until the week of his death.

Patrick left Queens to join the Canadian Museum of Nature 4 June 1991 after being individually recruited as Assistant Director Collections and Research. In a reorganization in 1994 he became Vice President for Science and Education. I think that perhaps Patrick felt that joining the museum was an opportunity to affect changes to national science policies, and certainly he had become interested in science management during the latter years of his tenure at Queen's. During this short period on the federal scene, he also served as a lecturer at the Canadian Centre for Management Development. While at the Canadian Museum of Nature, he instituted and led a Task Force on Canadian Biosystemics, authoring a major report on the state of systematics research and capacity in Canada in 1992. Unfortunately, not all the years at the Museum were the happiest for Patrick. He had to preside over downsizing of his staff in 1993 and then, ultimately, he too was caught in the net of continuing upheaval within the museum when his own position was terminated in April, effective 12 July 1997. Subsequently he wrote a moving essay on the affects of downsizing published in the *Globe and Mail* 19 September 1997 page A18. Facts and Arguments: After downsizing: letting go, moving on. When I lost my job, Canada lost another established scientist. But Marcia got a less challenging garden, a university got my science library, and the world has a new pair of B&B owners" which described his search for a new role and resettlement in warmer climate of the Niagara-on-the Lake in southern Ontario as tourist accommodation entrepreneurs

Immediately following his departure from the museum, Patrick made an extraordinarily generous gift of 10 000 books from his immense personal library, many volumes of which were rare, to Algoma University College in Sault Ste. Marie, and of another 1000 books to University of Northern British Columbia. At the same time, he donated his massive collection of more than 300 000 reprints to Memorial University.

After three years of B&B and sessional lecturer in evolution at Brock University, in 2001 he became Director of Research and Natural Lands at Royal Botanical Gardens. Here, he supervised the herbarium, library, research and natural lands projects, researchers and ecological managers. Patrick was also responsible for the stewardship of approximately 1000 hectares of natural lands that are owned and managed by RBG and he represented the institution in collaborations, such as the Bay Area Restoration Council. In 2001, Patrick explored a new relationship between RBG and indigenous peoples that resulted in a First Nations internship program in ethnobotany at RBG, supported by the Museum Assistance Program of the Government of Canada.

Patrick had a wonderful sense of humour, and enjoyed witticisms to no end. He sent the following memo to Queen's Financial Services Department that was printed in *Biology this Week* (the Queen's Biology Department newsletter): "For some time I have received some of my cheques from you made out to Patricia Colgan. Please be assured that this is an error, proof of which I should be happy to furnish if requested."

He was an avid chorister and spent many happy years singing with the Kingston Symphony Choral Society. Indeed, his curriculum vitae, submitted for promotion to Professor at Queen's University, contained two pages listing the choral works with which he had been involved during his time in Kingston. He continued his singing in Ottawa and again in Niagara/Hamilton, until his illness forced him to give up this joy in his life. Another Patrick passion was rare books, and many a graduate student was dragged in-tow into rare book stores across North America, while attending various conferences.

I can only imagine the frustration that such an illness brought to a man who was so extraordinarily full of energy. Patrick loved life. His enthusiasm for debate, knowledge, ideas, detailed thinking, books, mathematics, singing, sports, and family were contagious for those of us who were blessed enough to know him well. When I met Patrick, he was the consummate academic, brimming with ideas and revelling in constant questioning.

My personal involvement with Patrick began in 1981, when I asked Queen's University Biology Department to consider taking a mature student (some would have argued differently!) on an educational leave from the federal government to do a doctorate. There was apparently disagreement at the school over the issue, as this kind of arrangement had not previously been done. But, Patrick, ever respectful of motivated people and new ideas, simply asked "why not?", and stated emphatically that he would gladly step up as supervisor. And so, an unlikely alliance began between a forest wildlife ecologist and a fish behaviourist, and I found myself in a lab surrounded by fish folks. Patrick was a wonderful supervisor and participated fully with his students, academically in the lab, athletically at the rink and on the squash courts, and socially at the "Grad Club" or at various dinners at his home. A beer at the Grad Club after playing a hockey game was not an afternoon wasted to him. Aside from the alacrity and probity of the man, what probably struck me most about Patrick was that he never used what he knew was a superior intellect to demean others. Patrick became one of two people who were

highly influential in my professional life, as I know he also was for many other students who were fortunate enough to pass through his lab. He was, without a doubt, the most erudite person that I have ever met and all of us students benefitted immensely from his guidance, passion, and knowledge. The legacy of Patrick Colgan is a large number of well-established, well-recognized researchers doing important work across this country and abroad. I shall always remember his daily slogan: "onwards and upwards!" and I shall miss it.

Acknowledgments

My appreciation for their contributions to Marcia Sweet, Patrick's partner, to David Galbraith, Head of Scientific Development, Royal Botanical Gardens, to Raleigh Robertson, Head, Department of Biology, Queen's University, and to the late Florence (Susan) Smallman of Kingston.

Books Authored or Edited:

Colgan, Patrick. *Editor.* 1978. Quantitative Ethology. John Wiley & Sons, New York. ISBN: 0471022365

Colgan, Patrick W. 1983. Comparative Social Recognition. John Wiley & Sons, New York. ISBN: 0471093505

Colgan , Patrick W., and **Renâe Zayan.** *Editors.* 1986. Quantitative Models in Ethology. Université Paul Sabatier, Privat, Toulouse, France. ISBN: 2708987089.

Colgan, Patrick. 1989, Animal Motivation. Kluwer Academic Publishers Group, London. ISBN: 0412318504

Scientific papers (in chronological order)

Colgan, P. W. 1973. Motivational analysis of fish feeding. Behaviour 45: 38-66.

Colgan, P. W., and **D. Ealey.** 1973. The role of woody debris in nest site selection by pumpkinseed sunfish, *Lepomis gibbosus*. Canadian Fisheries Research Board Journal 30: 853-856.

Colgan, P. W., F. Cooke, and **J. T. Smith.** 1974. An analysis of group composition on assortatively mating populations. Biometrics 30: 693-696.

Colgan, P. W. 1974. Burying experiments with banded killifish, *Fundulus diaphanous.* Copeia 1974: 258-259.

Colgan, P. W. 1975. Self-selection of photoperiod as a technique for studying endogenous rhythms in fish. Journal of Interdisciplinary Cycle Research 6: 203-211.

Colgan, P. W., P. K. Ballantyne, and **N. V. H. Wilson.** 1976. Numerical taxonomy of hybridizing *Lepomis centrarchidae* in Lake Opinicon, Ontario, Canada. Canadian Journal of Zoology 54: 42-47.

Colgan, P. W., and **M. R. Gross.** 1977. Dynamics of aggression in male pumpkinseed sunfish (*Lepomis gibbosus*) over reproductive phase. Zeitschrift Fur Tierpsychologie 43: 139-151.

Colgan, P. W. 1978. Modeling. *In* Quantitative Ethology. *Edited by* P. W. Colgan. Wiley Inter-Science, New York.

Colgan, P. W., and **T. J. Smith.** 1978. Multidimensional contingency table analysis. Pages 146-174 *in* Quantitative Ethology. *Edited by* P. W. Colgan. Wiley, New York.

Ballantyne, P. K., and **P. W. Colgan.** 1978. Sound production during agonistic and reproductive behaviour in the pumpkinseed (*Lepomis gibbosus*), the bluegill (*L. macrohirus*) and their hybrid sunfish. I. Context. Biology of Behaviour 3: 113-135.

Ballantyne, P. K., and **P. W. Colgan.** 1978. Sound production during agonistic and reproductive behaviour in the pumpkinseed (*Lepomis gibbosus*), the bluegill (*L. macrohirus*) and their hybrid sunfish. 2. Recipients. Biology of Behaviour 3: 207-220.

Ballantyne, P. K., and **P. W. Colgan.** 1978. Sound production during agonistic and reproductive behaviour in the pumpkinseed (*Lepomis gibbosus*), the bluegill (*L. macrohirus*) and their hybrid sunfish. 3. Response. Biology of Behaviour 3: 221-232.

Colgan, P. W., W. A. Nowell, M. R. Gross, and **J. W. A. Grant.** 1979. Aggressive habituation and rim circling in the social organization of bluegill sunfish (*Lepomis macrochirus*). Environmental Biology of Fishes 4: 29-36.

Colgan, P. W. 1979. Is super territory strategy stable? American Naturalist 114: 604-605.

Colgan, P. W., and **N. Costeloe.** 1980. Plasticity of burying behavior by the banded killifish, *Fundulus diaphanous*. Copeia 1980: 349-351.

Colgan, P. W., and **P. J. B. Slater.** 1980. Clustering acts from transition matrices. Animal Behaviour 28: 965-966.

Colgan, P. W., and **P. Taylor.** 1980. Sex-ratio in autoparasitic hymenoptera. American Naturalist 117: 564-566. Healey, R. F., F. Cooke, and P. Colgan. 1980. Demographic consequences of snow goose brood rearing conditions. Journal of Wildlife Management 44: 900-905.

Slater, P. J. B., S. A. Ince, and **P.W. Colgan.** 1980. Chaffinch *Fringilla coelebs* song types: their frequencies in the population and distribution between repertories of different individuals. Behaviour 75: 207-218.

Colgan, P. W., W. A. Nowell, and **N. W. Stokes.** 1981. Spatial aspects of nest defence by pumpkinseed sunfish (*Lepomis gibbosus*): stimulus features and an application of catastrophe theory. Animal Behaviour 29: 433-442.

Brown, J. A., and **P. W. Colgan.** 1981. The use of lateral-body bar markings in identification of young-of-year sunfish (Lepomis) in Lake Opinicon, Ontario. Canadian Journal of Zoology 59: 1852-1855.

Yee, J., L. Broekhoven, P. Colgan, and **R. Harmsen.** 1981. Maximal growth rate determination using continuous culture. Journal of Protozoology 28: 146-148.

Brown, J. A., and **P .W. Colgan.** 1982. The inshore vertical distribution of young-of-year *Lepomis* in Lake Opinicon, Ontario. Copeia 1982: 958-960.

Colgan, P. W., and **J. A. Cross.** 1982. Laboratory food patch exploitation in the algae-eater (*Gyrinocheilus ayomonieri*). Biological Behaviour 7: 109-117.

Colgan, P. W., J. A. Cross, and **P. H. Johansen.** 1982. Guppy behavior during exposure to a sub-lethal concentration of phenol. Bulletin of Environmental Contamination and Toxicology 28: 20-27.

Grant, J. W., and **P. W. Colgan.** 1983. Reproductive success and mate choice in the Johnny darter, *Etheostoma nigrum* (Pisces: Percidae). Canadian Journal of Zoology 61: 437-446.

Grant, J. W. A., and **P. W. Colgan.** 1984. Territorial defence of the male Johnny darter, *Etheostoma nigrum*, Environmental Biology of Fishes 10: 261-269.

Clarke, S. E., P. W. Colgan, and **N. P. Lester.** 1984. Courtship sequences and ethological isolation in two species of sunfish (*Lepomis* spp.) and their hybrids. Behaviour 91: 93-114.

Brown, J. A., and **P. W. Colgan.** 1984. The ontogeny of feeding behaviour in four species of centrarchid fish. Behavioral Proceedings 9: 395-411.

Colgan, P., and B. Silburt. 1984. Feeding behavior of the central mud minnow, *Umbra limi*, in the field and laboratory. Environmental Biology of Fishes 10: 209-214.

Colgan, P. W., and **T. J. Smith.** 1985. Experimental analysis of food preference transitivity in pumpkinseed fish (*Lepomis gibbosis*). Biometrics 41: 227-236.

Hilder, B. E., and **P. W. Colgan.** 1985. Territorial behaviour of male *Nannothemis bella* (Uhler) (Anisoptera: Libellulidae). Canadian Journal of Zoology 63: 1010-1016.

Abrahams, M. V., and **P. W. Colgan.** 1985. Risk of predation, hydrodynamic efficiency and their influence on school structure. Environmental Biology of Fishes 13: 195-202.

Brown, J. A., P. H. Johansen, and **P. W. Colgan.** 1985. Subtle changes in the predator-avoidance behaviour of the guppy (*Poecilia reticulata*) after exposure to Pentachlorophenol. Canadian Journal of Zoology 63: 2001-2005.

Brown, J.A., and **P. W. Colgan.** 1985. Interspecific differences in the ontogeny of feeding behaviour in two species of centrarchid fish. Zeitschrift Fur Tierpsychologie 70: 70-80.

Brown, J. A., and **P. W. Colgan.** 1985. The ontogeny of social behaviour in four species of centrarchid fish. Behaviour 92: 254-276.

Johansen, P. H., A. R. Mathers, J. A Brown, and **P. W. Colgan.** 1985. Mortality of early life stages of largemouth bass juveniles due to pentachlorophenol exposure. Bulletin of Environmental Contamination and Toxicology 34: 377-384.

Colgan, P. W., and **A. B. Salmon.** 1986. Breeding experience and parental behaviour in convict cichlads (*Cichlasoma nigrofasciatum*). Behavioural Processes 13: 101-118.

Colgan, P. W., J. A. Brown, and **S. Orsatti.** 1986. Role of diet and experience in the development of feeding behaviour in largemouth bass (*Micropterus salmoides*). Journal of Fisheries Biology 28: 161-170.

Brown, J. A., and **P. W. Colgan.** 1986. Individual and species recognition in centrarchid fishes: evidence and hypothesis. Behavioural Ecology and Sociobiology 19:373-379.

Colgan, P. W. 1986. The motivational basis of fish behaviour. Pages 23-46 *in* The behaviour of teleost fishes. *Edited by* T. J. Pitcher. Croom Helm, London.

Eadie, J. M., L. Broekhoven, and **P. W. Colgan.** 1986. Size ratios and artifacts: Hutchison's rule re-visited. American Naturalist 129: 1-17.

Johansen, P. H., A. R. Mathers, J. A. Brown, and **P. W. Colgan.** 1987. Growth of largemouth bass juveniles exposed to various concentrations of pentachlorophenol. Bulletin of Environmental Contamination and Toxicology 39: 379-384.

Abrahams, M. V., and **P. W. Colgan.** 1987. Fish schools and their hydrodynamic function: a reanalysis. Environmental Biology of Fishes 20: 79-80.

Gotceitas, V., and **P. W. Colgan.** 1987. Selection between densities of vegetation by young bluegill sunfish (*Lapomis macrochirus*) when avoiding predation. Transactions of American Fisheries Society 116: 40-49.

Morgan, M. J., and **P. W. Colgan.** 1987. The effects of predation presence and shoal size on foraging and bluntnose minnows, *Pimephales notatus*. Environmental Biology of Fishes 20: 105-111.

Orsatti, S. D., and **P. W. Colgan.** 1987. Effects of sulphuric acid exposure on the behaviour of largemouth bass, *Micropterus salmoides*. Environmental Biology of Fishes 19: 119-129.

Brown, J. A., P. H. Johansen, P. W. Colgan, and **A. R. Mathers.** 1987. Exposure to Pentachlorophenol impairs the early feeding behaviour of largemouth bass (*Micropterus salmoides*). Transactions of the American Fisheries Society 116: 71-78.

Thompson, I. D., and **P. W. Colgan.** 1987. Numerical responses of martens to a food shortage in northcentral Ontario. Journal of Wildlife Management 51: 824-835.

Morgan, M. J., and **P. W. Colgan.** 1988. The role of experience in foraging shoals of bluntnose minnows (*Pimephales notatus*). Behavioural Processes 16: 87-94.

Colgan, P. W., and **J. A. Brown.**1988. Dynamics of nest defense of male centrarchid fish. Behavioural Processes 17: 17-26.

Gotceitas, V., and **P. W. Colgan.** 1988. Individual variation in learning by foraging juvenile bluegill sunfish (*Lepomis macrochirus*). Journal of Comparative Psychology 102: 294-299.

Gotceitas, V., and **P. W. Colgan.** 1989. Predator foraging success and habitat complexity: a quantitative test of the threshold hypothesis. Oecologia 80: 168-166.

Crawford, S. S., and **P. W. Colgan.** 1989. Motivational models of courtship in male three-spine sticklebacks *Gasterosteus aculeatus*. Behaviour 109: 285-302.

Jamieson, I. G., and **P. W. Colgan.** 1989. Eggs in the nests of males and their effect on mate choice in the three-spined stickleback. Animal Behaviour 38: 859-865.

Colgan, P. W., T. L. Jamieson, J. E. Frame, and **J .T. Smith.** 1990. Simulation Studies of Song Learning in Birds 281 *in* From animals to animats. Proceedings of the First International Conference on Simulation of Adaptive Behavior. *Edited by* Jean-Arcady Meyer and Stewart W. Wilson. The MIT Press: Cambridge, Massachusetts.

Gotceitas, V., and **P. W. Colgan.** 1990. The effects of prey availability and predation risk on habitat selection by juvenile bluegill sunfish. Copeia 1990: 407-409.

Gotceitas, V., and **P. W. Colgan.** 1990. Behavioural response of juvenile bluegill sunfish to variation in predation risk and food level. Ethology 85: 247-255.

Reebs, S. G., and **P. W. Colgan.** 1990. Nocturnal care of eggs and circadian rhythms of fanning activity in two normally diurnal cichlid fishes, *Cichlasoma nigrofasciatum* and *Herotilapia multispinosa*. Animal Behaviour 41: 303-311.

Gotceitas, V., and **P. W. Colgan.** 1991. Assessment of patch profitability and ideal free distribution: the significance of sampling. Behaviour 119: 65-76.

Colgan P., V. Gotceitas, and **J. Frame.** 1991. Individual variation, acquisition, and reacquisition in a foraging task by juvenile bluegill sunfish (*Lepomis macrochirus*). Journal of Comparative Psychology 105: 78-84.

Gabora, L., and **P. Colgan**. 1991. A model of the mechanisms underlying exploratory behavior. *In* From Animals to Animats: Proceedings of the First International Conference on Simulation of Adaptive Behavior. *Edited by* Jean-Arcady Meyer and Stewart W. Wilson. The MIT Press: Cambridge, Massachusetts.

Kieffer, J. D., and **P. W. Colgan.** 1991. Individual variation in learning by foraging pumpkinseed sunfish *Lepomis* gibbosis: the influence of habitat. Animal Behaviour 41: 603-612.

Lavery, R. J., and **P. W. Colgan.** 1991. Brood age and parental defence in the convict cichlid. Animal Behaviour 41: 945-952.

Samis, A. J. W., P. W. Colgan, and **P. H. Johansen.** 1991. A comparison of the effects of subchronic and acute spill-mimicking pentachlorophenol exposures on growth of bluegill sunfish (*Lepomis macrochirus*). Aquatic Toxicology 19: 231-240.

Thompson, I. D., and **P. W. Colgan.** 1991. Prey choice by marten during a decline in prey abundance. Oecologia 83: 443-451.

Langley, R. G., J. W. Driscoll, and **P. W. Colgan.** 1992. Diurnal rhythms of activity in three species of sunfish (*Lepomis* spp.) Journal of Interdisciplinary Cycle Research 24: 56-64.

Jamieson, I. G., and **P. W. Colgan.** 1992. Sneak spawning and egg stealing by male three-spine sticklebacks. Canadian Journal of Zoology 70: 963-967

Jamieson, I. G., D. M. Blouw, and **P. W. Colgan.** 1992. Parental care as a constraint on male matching success in fishes in a comparative study of threespine and white sticklebacks. Canadian Journal of Zoology 70: 956-962.

Jamieson, I. G, D. M. Blouw, and **P. W. Colgan.** 1992. Observations on the reproductive biology of a newly discovered stickleback *Gasterosteous.* Canadian Journal of Zoology 70: 1057-1063.

Kieffer, J. D., and **P. W. Colgan.** 1992. The role of learning in fish behaviour. Reviews in Fish Biology 2: 125-143.

Kieffer, J. D., and **P. W. Colgan.** 1992. Differences in learning by foraging juvenile pumpkinseed and bluegill sunfish in a structured habitat. Environmental Biology of Fishes 33: 359-366.

Reebs, S. G., and **P. W. Colgan.** 1992. Proximal cues for nocturnal egg care in convict cichlids, *Cichlasoma nigrofasciatum.* Animal Behaviour 43: 209-214.

Kieffer, J. D., and **P. W. Colgan.** 1993. Foraging flexibility in pumpkinseed (*Lepomis gibbosus*): Influence of habitat structure and prey type. Canadian Journal of Fisheries and Aquatic Sciences 50: 1699-1705.

Waas, J. R., and **P. W. Colgan.** 1993. Chemical cues associated with the visually elaborate aggressive displays of three-spine sticklebacks. Journal of Chemical Ecology 18: 2277-2284.

Thompson, I. D., and **P. W. Colgan.** 1994. Marten activity in uncut and logged boreal forests in Ontario. Journal of Wildlife Management 58: 280-288.

Waas, J. R., and **P. W. Colgan.** 1994. Male sticklebacks can distinguish between familiar rivals on the basis of visual cues alone. Animal Behaviour 47: 7-13.

Samis, A. J. W., P. W. Colgan, and **P. H. Johansen.** 1995. Recovery from the effects of subchronic pentachlorophenol exposure on growth of juvenile bluegill sunfish (*Lepomis macrochirus*). Canadian Journal of Zoology 72: 1993-1977.

Waas, J. R., M. Caulfield, P. W. Colgan, and **P. T. Boag.** 2000. Colony sound facilitates sex and agonistic activities in royal penguins. Animal Behaviour 60: 77-84.

Book Reviews from 1978-2004 [reviews after 1997 were incompletely recorded in Patrick's files, but those in the *Canadian Field-Naturalist* and *the Book Review Annual* for 1998-2004 were compiled and added by F. R. Cook. from these publications.]

Colgan, P. 1978. Review of R. Dawkins: The Selfish Gene. Environmental Biology of Fishes 3: 327-328.

Colgan, P. 1980. Review of E. S. Reese and F. J. Lighter (*Editors*): Contrasts in Behaviour. Behavioural Processes 5: 81-82.

Colgan, P. 1980. Review of D. Mostofsky (*Editor*): The Behavior of Fish and Other Aquatic Organisms. Behavioural Processes 5: 82-83.

Colgan, P. 1981. Review of M. D. Zeiler and R. Harzem (*Editors*): Reinforcement and the Organization of Behaviour. Behavioural Processes 6: 96-97.

Colgan, P. 1981. Review of R. Cattell: The Scientific use of Factor Analysis in Behavioural and Life Sciences. Behavioural Processes 6: 385-386.

Colgan, P. 1981. Review of J. T. Bonner: The Evolution of Culture in Animals. Canadian Field-Naturalist 95: 221-222.

Colgan, P. 1982. Review of F. Toates: Animal Behaviour – A Systems Approach. Behavioural Processes 7: 189-190.

Colgan, P. 1982. Review of D. M. Broom: Biology of Behaviour. Quarterly Review of Biology 57: 488.

Colgan, P. 1983. Review of W. N. Tavolga, A. N. Popper, and A. A. Fay (*Editors*): Hearing and Sound Communication in Fishes. Behavioural Processes 8: 205-206.

Colgan, P. 1983. Review of P. W. Witt and J. S. Rovner (*Editors*): Spider Communication. Canadian Field Naturalist 97: 246.

Colgan, P. 1983. Review of K. P. Burnham et al.: Estimation of Density from Line Transect Sampling of Biological Populations. Canadian Field-Naturalist 97: 246.

Colgan, P. 1983. Review of F. O. Pinto and B. W. Conolly (*Editors*): Applicable Mathematics of Non-physical Phenomena. Quarterly Review of Biology 58: 312.

Colgan, P. 1984. Review of C. J. Barnard: Animal Behaviour, Ecology and Evolution. Behavioural Processes 9: 103.

Colgan, P. 1984. Review of G. Davey (*Editor*): Animal Models of Human Behaviour. Behavioural Processes 9: 104-105.

Colgan, P. 1984. Review of J. Gould: Ethology. Queen's Quarterly 91: 202-204.

Colgan, P. 1985. Review of P. P. G. Bateson and P. M. Klopfer (*Editors*): Perspectives in Ethology. Volume 5 Ontogeny. Behavioural Processes 10: 206-207.

Colgan, P. 1985. Review of R. Payne: (*Editor*): Communication and Behavior of Whales. Canadian Field-Naturalist 99: 276.

Colgan, P. 1985. Review of R. Jellis: Bird Sounds and Their Meaning. Canadian Field-Naturalist 99: 282.

Colgan, P. 1985. Review of G. L. Wood: The Guinness Book of Animal Facts and Feats. Canadian Field-Naturalist 99: 283.

Colgan, P. 1985. Review of J. R. Krebs and N. B. Davies (*Editors*): Behavioural Ecology: An Evolutionary Approach. Canadian Field-Naturalist 99: 455-456.

Colgan, P. 1985. Review of R. R. Baker's Bird Migration: The Solution of a Mystery? Canadian Field-Naturalist 99: 457-458.

Colgan, P. 1986. Review of M. Ridley: The Explanation of Organic Diversity: The comparative method and adaptations for mating. Behavioural Processes 11: 220-221.

Colgan, P. 1986. Review of R. M. Sibly and R. H. Smith (*Editors*): Behavioural Ecology. Bioscience 36: 682-683.

Colgan, P. 1986. Review of H. Schone: Spatial orientation. Canadian Field-Naturalist 100: 295.

Colgan, P. 1986. Review of R. I. M. Dunbar: Reproductive Decisions. Canadian Field-Naturalist 100: 295.

Colgan, P. 1986. Review of B. Holldobler and M. Lindauer (*Editors*): Experimental Behavioural Ecology and Sociobiology. Canadian Field-Naturalist 100: 444.

Colgan, P. 1986. Reviews of P. Kitcher: Vaulting Ambition; S. Rose et al.: Not in Our Genes; J. Q. Wilson and R. J. Herrnstein: Crime and Human Nature. Queen's Quarterly 93: 595-612.

Colgan, P. 1987. Review of P. Martin and P. Bateson (*Editors*): Measuring Behaviour – An introductory Study Guide. Behavioural Processes 15: 347-349.

Colgan, P. 1987. Review of P. J. B. Slater: An Introduction to Ethology. Canadian Field-Naturalist 101: 497.

Colgan, P. 1987. Review of M. E. Feder and G. V. Lauder (*Editors*): Predator prey relationships: Perspectives and approaches from the study of lower vertebrates. Canadian Field-Naturalist 101: 504-505.

Colgan, P. 1987. Review of J. A. Endler: Natural Selection in the Wild. Canadian Field-Naturalist 101: 508 – 509.

Colgan, P. 1987. Review of A. C. Kamil et al. (*Editors):* Foraging Behavior. Quarterly Review of Biology 63: 122.

Colgan, P. 1987. Review of H. J. V. Nossal: Reshaping Life. Queen's Quarterly 93: 938-940.

Colgan, P. 1988. Review of D. I. Rubenstein and R. W. Wrangham (*Editor*): Ecological Aspects of Social Evolution Birds and Mammals. Canadian Field-Naturalist 102: 177-179.

Colgan, P. 1988. Review of R. J. Hoage and L. Goldman: Animal Intelligence. Canadian Field-Naturalist 102: 589-590.

Colgan, P. 1988. Review of J. R. Krebs and N. B. Davies: An Introduction to Behavioural Ecology. Canadian Field-Naturalist 102: 590-591.

Colgan, P. 1988. Review of P. J. B. Slater (*Editor*): The Encyclopedia of Animal Behavior. Canadian Field-Naturalist 102: 591.

Colgan, P. 1988. Review of J. L. Brown: Helping and Communal Breeding in Birds: Ecology and Evolution. Canadian Field-Naturalist 102: 749-750.

Colgan, P. 1988. Review of D. W. Stephens and J. R. Kreb: Foraging Theory. Canadian Field-Naturalist 102: 750-751.

Colgan, P. 1988. Review of D. Sharpe: Rochdale. Queen's Quarterly 95: 715-716.

Colgan, P. 1988. Review of D. Suzuki: Metamorphosis. Queen's Quarterly 95: 753-754.

Colgan, P. 1988. Review of R. Augros and G. Stanciu: The New Biology. Queen's Quarterly 95: 945-947.

Colgan, P. 1989. Review of W. Koenig and R. L. Mumm: Population Ecology of the Cooperatively Breeding Acorn Woodpecker. Canadian Field-Naturalist 103: 109-110.

Colgan, P. 1989. Review of A. T. Bergerud and M. W. Gratson: Adaptive Strategies and Population Ecology of Northern Grouse. Canadian Field-Naturalist 103: 450-451.

Colgan, P. 1989. Review of C. Meine: Aldo Leopold. Canadian Field-Naturalist 103: 467-468.

Colgan, P. 1989. Review of T. Seddon: Animal Vision. Canadian Field-Naturalist 103: 473.

Colgan, P. 1989. Review of J. Bailey: Mimicry and Camouflage. Canadian Field-Naturalist 103: 473.

Colgan, P. 1989. Review of B. D. C. Sade and Z. T. Halpin (*Editors*): Mammalian Dispersal Patterns. Canadian Field-Naturalist 103: 616-617.

Colgan, P. 1990. Review of P. P. G. Bateson and P. H. Klopfer (*Editors*): Perspectives in Ethology Volume 8. Bioscience 40: 148-149.

Colgan, P. 1990. Review of J. Alcock: The Kookaburras' Song. Canadian Field-Naturalist 103: 618.

Colgan, P. 1990. Review of L. Brown and J. Downhower: Analyses in Behavioural Ecology. Canadian Field-Naturalist 104: 150-151.

Colgan, P. 1990. Review of T. H. Waterman: Animal Navigation. Canadian Field-Naturalist 104: 331-332.

Colgan, P. 1990. Review of D. Morse: American Warblers. Canadian Field-Naturalist 104: 502.

Colgan, P. 1990. Review of P. Anderson: Dispersal in Rodents: A Resident Fitness Hypothesis. Canadian Field-Naturalist 104: 503-504.

Colgan, P. 1990. Review of T. Seddon: Animal Parenting. Canadian Field-Naturalist 104: 515.

Colgan, P. 1991. Review of J. P. Rauschecker and P. Marler (*Editors)*: Imprinting and Cortical Plasticity: Comparative Aspects of Sensitive Periods. Behavioural Processes 23: 153–155.

Colgan, P. 1991. Review of D.A. Dewsbury (*Editor*): Studying Animal Behavior. Canadian Field-Naturalist 105: 309–310.

Colgan, P. 1991. Review of S. B. Vanderwall: Food Hoarding in Animals. Canadian Field-Naturalist 105: 438.

Colgan, P. 1991. Review of R. Burton's Bird Flight. Canadian Field-Naturalist 105: 604.

Colgan, P. 1991. Review of G. Weissmann: The Doctor with Two Heads. Queen's Quarterly 98: 248–249.

Colgan, P., and **I. Jamieson.** 1991. Review of M. Clark: The Optimization Approach to Behavior. Behaviourial and Brain Sciences 14: 95–96.

Colgan, P. 1991. Review of J. A. Burnett, C. T. Dauphiné, S. H. McCrindle, and T. Mosquin: On the Brink: Endangered Species in Canada. Canadian Biodiversity 1(3): 48-49.

Colgan, P. 1992. Review of P. W. Dowrick (*Editor)*: Practical Guide to Using Video in the Behavioral Sciences. Behavioural Processes 26: 59-60.

Colgan, P. 1992. Review of P. P. G. Bateson and P. H. Klopfer (*Editors*): Perspectives in Ethology Volume 9. Human Understanding and Animal Awareness. Behavioural Processes 26: 60–61.

Colgan, P. 1992. Review of R. M. Hughes (*Editor*): Behavioural Mechanisms of Food Selection. Behavioural Processes 27: 151–152.

Colgan, P. 1992. Review of B. Kramer's Electrocommunication in Teleost Fishes. Behavioural Processes 27: 152–153.

Colgan, P. 1992. Review of T. A. Sebeok: A Sign is Just a Sign. Behavioural Processes 27: 219.

Colgan, P. 1992. Review of D. H. Meadows, D. L. Meadows, and J. Randers: Beyond the Limits. Canadian Biodiversity 2(3): 52–53.

Colgan, P. 1992. Review of A. M. Wenner and P. H. Wells: Anatomy of a Controversy. Canadian Field-Naturalist 106: 154.

Colgan, P. 1992. Review of M. Bekoff and D. Jamieson (*Editor*): Interpretation and Explanation in the Study of Animal Behavior. Canadian Field-Naturalist 106: 157-158.

Colgan, P. 1992. Review of D. R. Brooks and D. A. McLennan: Phylogeny, Ecology, and Behavior. Canadian Field-Naturalist 106: 279-280.

Colgan, P. 1992. Review of T. H. C. Brock: The Evolution of Parental Care. Canadian Field-Naturalist 106: 279.

Colgan, P. 1992. Review of S. T. Parker and K. R. Gibson (*Editors*): "Language" and intelligence in monkeys and apes. Canadian Field-Naturalist 106: 285-286.

Colgan, P. 1992. Review of P. B. Sanders: Carl Akeley. Canadian Field-Naturalist 106: 298.

Colgan, P. 1992. Review of R. A. Croker: Pioneer Ecologist The Life and Work of Victor Ernest Shelford. Canadian Field-Naturalist 106: 422.

Colgan, P. 1992. Review of T. Heuss: Anton Dohrn A Life for Science. Canadian Field-Naturalist 106: 550.

Colgan, P. 1993. Review of J. Vauclair: L 'intelligence de l'animal. Behavioural Processes 29: 162.

Colgan, P. 1993. Review of P. Haccou and E. Meelis: Statistical Analysis of Behavioural Data. Behavioural Processes 29: 163

Colgan, P. 1993. Review of P.K. McGregor: Playback and Studies of Animal Communication. Behavioural Processes 30: 87-88.

Colgan, P. 1993. Review of J. Foster et al. (*Editors*) Buffalo. Canadian Book Review Annual: 491-492.

Colgan, P. 1993. Review of E. Claridge and B. A. Miligan: Animal Signatures. Canadian Book Review Annual: 492-493.

Colgan, P. 1993. Review of E. Hoyt: Riding with the Dolphins. Canadian Book Review Annual: 495.

Colgan, P. 1993. Review of Peterborough Field Naturalists: Kawarthas Nature. Canadian Book Review Annual: 496-497.

Colgan, P. 1993. Review of W. Barrett and G. Saunders: Wildlife of Atlantic Canada and New England. Canadian Book Review Annual: 500.

Colgan, P. 1993. Review of L. Labatt and B. Littlejohn: Islands of Hope. Canadian Book Review Annual: 504-505.

Colgan, P. 1993. Review of F. Gregory: Nature lost? Canadian Field-Naturalist 107: 135.

Colgan, P. 1993. Review of D. R. Giffin: Animal Minds. Canadian Field-Naturalist 107: 258-259.

Colgan, P. 1993. Review of G. B. Goode: The Origins of Natural Science in America. Canadian Field-Naturalist 107: 262.

Colgan, P. 1993. Review of I. Tree: The Ruling Passion of John Gould. Canadian Field-Naturalist 107: 389.

Colgan, P. 1993. Review of E. C. Hargrove: The Animal Rights/Environmental Ethics Debate. Canadian Field-Naturalist 107: 557.

Colgan, P. 1994. Review of R. Stoltmann: Written by the Wind. Canadian Book Review Annual: 1073.

Colgan, P. 1994. Review of N. Evernden: The Natural Alien. Canadian Book Review Annual: 2127.

Colgan, P. 1994. Review of F. Bruemmer: The Narwhal. Canadian Book Review Annual: 5002.

Colgan, P. 1994. Review of D. W. Nagorsen and R. M. Brigham: Bats of British Columbia. Canadian Book Review Annual: 5011.

Colgan, P. 1994. Review of B. Obee: Canadian Wildlife. Canadian Book Review Annual: 5013.

Colgan, P. 1994. Review of S. H. Paine: Beachwalker Sea Life of the West Coast. Canadian Book Review Annual: 5014.

Colgan, P. 1994. Review of D. Sanders and D. Swanson: The Emerald Sea. Canadian Book Review Annual: 5018.

Colgan, P. 1994. Review of D. A. E. Spalding: Dinosaur Hunters. Canadian Book Review Annual: 5019.

Colgan, P. 1994. Review of J. B. Stelfox: Hoofed Mammals of Alberta. Canadian Book Review Annual: 5020.

Colgan, P. 1994. Review of D. Swanson: Why Seals Blow their Noses. Canadian Book Review Annual: 6307.

Colgan, P. 1994. Review of A. Morton: In the Company of Whales. Canadian Book Review Annual: 6302.

Colgan, P. 1994. Review of P. B. Moyle: Fish for Enthusiast's Guide. Canadian Field-Naturalist 108: 261.

Colgan, P. 1994. Review of P. A. Johnsgard: Arena Birds. Canadian Field-Naturalist 108: 386-387.

Colgan, P. 1994. Review of M. A. Ali (*Editor*): Rhythms in Fishes. Canadian Field-Naturalist 108: 502.

Colgan, P. 1994. Review of T. Halliday (*Editor*): Animal Behavior. Canadian Field-Naturalist 108: 503.

Colgan, P. 1995. Review of R. V. Short and E. Balaban (*Editors*): The Differences between the Sexes. Behavioural Proceedings 34: 103-104.

Colgan, P. 1995. Review of M. Newman: Life in a Fishbowl. Canadian Book Review Annual: 2072.

Colgan, P. 1995. Review of P. Watson: Ocean Warrior. Canadian Book Review Annual: 2097.

Colgan, P. 1995. Review of K. E. Von Maltzahn: Nature as Landscape. Canadian Book Review Annual: 4230.

Colgan, P. 1995. Review of W. Grady: Coyotes. Canadian Book Review Annual: 5002.

Colgan, P. 1995. Review of P. Kochanoff: Nearby Nature. Canadian Book Review Annual: 5006.

Colgan, P. 1995. Review of R. Ludvigsen and G. Beard: West Coast Fossils. Canadian Book Review Annual: 5008.

Colgan, P. 1995. Review of B. Obee: Wolf. Canadian Book Review Annual: 5013.

Colgan, P. 1995. Review of C. Russell: Spirit Bear. Canadian Book Review Annual: 5014.

Colgan, P. 1995. Review of H. Thurston: Dawning of the Dinosaurs. Canadian Book Review Annual: 5015.

Colgan, P. 1995. Review of R. Busch: Wolf Songs. Canadian Book Review Annual: 5016.

Colgan, P. 1995. Review of D. Wood: Wolves. Canadian Book Review Annual: 5017.

Colgan, P. 1995. Review of A. Carr: A Naturalist in Florida. Canadian Field-Naturalist 109: 141.

Colgan, P. 1995. Review of L.A. Real (*Editor*): Behavioral Mechanisms in Evolutionary Ecology. Canadian Field-Naturalist 109: 490-491.

Colgan, P. 1995. Review of D. Lindsay: Science in the Subarctic. Canadian Field-Naturalist 109: 512–513.

Colgan, P. 1995. Review of E. Sober: From a Logical Point of View. Canadian Field-Naturalist 109: 514.

Colgan, P. 1996. Review of D. J. Depew and B. M. Weber: Darwinism Evolving. Canadian Field-Naturalist 109: 515.

Colgan, P. 1995. Review of L. S. Hamilton (*Editor*): Ethics Religion and Biodiversity: Relations between Conservation and Cultural Values. Global Biodiversity 5(2): 46–47.

Colgan, P. 1995. Review of L. Grande and O. Rieppel (*Editors*): Interpreting the Hierarchy of Nature. From Systematic Patterns to Evolutionary Process Theories. Global Biodiversity 5(3): 39.

Colgan, P. 1995. Review of P. S. Cato and C. Jones (*Editors*): Natural History Museums Directions for Growth. Natural History Conservation 9: 5.

Colgan, P. 1995. Review of Recent Setbacks in Conservation. Natural History Conservation 9: 5.

Colgan, P. 1995. Review of J. H. Schroder and al.: Trends in Ichthyology. Reviews of Fish Biology and Fisheries 5: 258–259.

Colgan, P. 1996. Review of N. S. Thompson (*Editor*): Perspectives in Ethology. II Behavioural Design. Behaviour Processes 37: 251 -252.

Colgan, P. 1996. Review of J. A. Hogan and J. J. Bolhuis (*Editors*): Causal Mechanisms of Behavioural Development. Behavioural Processes 37: 253–254.

Colgan, P. 1996. Review of R. Wong (*Editor*): Biological Perspectives on Motivated Activities. Behavioural Processes 37: 265–266.

Colgan, P. 1996. Review of B. J. Christie: The Horses of Sable Island. Canadian Book Review Annual: 5002.

Colgan, P. 1996. Review of R. L. Grambo: The Nature of Foxes. Canadian Book Review Annual: 5007.

Colgan, P. 1996. Review of S. H. Paine: The Nature of Arctic Whales. Canadian Book Review Annual: 5013.

Colgan, P. 1996. Review of G. Parker: Eastern Coyote. Canadian Book Review Annual: 5014.

Colgan, P. 1996. Review of F. Stewart (*Editor*): The Presence of Whales. Canadian Book Review Annual: 5016.

Colgan, P. 1996. Review of K. Scott: Hiking in Bear Country. Canadian Book Review Annual: 5018.

Colgan, P. 1996. Review of M. Snyderman: Shark. Canadian Book Review Annual: 5020

Colgan, P. 1996. Review of D. Thomas and M. Enns: Grizzly Kingdom. Canadian Book Review Annual: 5021.

Colgan, P. 1996. Review of M. Matthen and R. X. Ware (*Editors*): Biology and Society. Canadian Book Review Annual: 5043.

Colgan, P. 1996. Review of T. Everts and B. Kalman: Really Weird Animals. Canadian Book Review Annual: 6310.

Colgan, P. 1996. Review of E. S. Grace: Apes. Canadian Book Review Annual: 6314.

Colgan, P. 1996. Review of B. Kalman: Penguins. Canadian Book Review Annual: 6318.

Colgan, P. 1996. Review of W. Lynch: Bears Bears Bears. Canadian Book Review Annual: 6322.

Colgan, P. 1996. Review of A. Mason: Oceans. Canadian Book Review Annual: 6324.

Colgan, P. 1996. Review of D. Swanson: Sky Dancers. Canadian Book Review Annual: 6335.

Colgan, P. 1996. Review of M. Ruse: Evolutionary Naturalism. Canadian Field-Naturalist 110: 568.

Colgan, P. 1996. Review of S. R. Kellert: The Value of Life: Biological Diversity and Human Existence. Global Biodiversity 6(3): 43-44.

Colgan, P. 1996. Review of B. G. Nortonsea Cumb et al. (*Editors*): Ethics on the Ark: Zoos, Animal Welfare, and Wildlife Conservaion. Global Biodiversity 6(2): 44.

Colgan, P. 1996. Review of J. N. Thompson: The Coevolutionary Process. Global Biodiversity 6(2): 44-45.

Colgan, P. 1997. Review of D. Takacs: The Idea of Biodiversity: Philosophies of Paradise. Global Biodiversity 7(1): 46.

Colgan, P. 1997. Review of Animal Cognition: An Introduction to Modern Comparative Osycology 41: 292.

Colgan, P. 1997. Review of K. Lorenz: The Natural Science of the Human Species. Behavioural Processes 41: 211.

Colgan, P. 1997. Review of M. Dol et al. (*Editor*): Animal Consciousness and Animal Ethics. Behavioural Processes 41: 211-212.

Colgan, P. 1997. Review of E. Bauer: Bears: Behavior, Ecology, Conservation. Canadian Book Review Annual: 2004

Colgan, P. 1997. Review of J. S. Bleakney: Sea Slugs of Atlantic Canada and the Gulf of Mexico. Canadian Book Review Annual: 5005.

Colgan, P. 1997. Review of R. Cannings and S. Cannings: British Columbia: A Natural History. Canadian Book Review Annual: 5007.

Colgan, P. 1997. Review of D. Dekker: Wolves in the Rocky Mountains from Jasper to Yellowstone. Canadian Book Review Annual: 5012.

Colgan, P. 1997. Review of R. Orenstein (*Editor*): Elephants: The Deciding Decade. Canadian Book Review Annual: 5013.

Colgan, P. 1997. Review of R. M. Harbo: Shells and Shellfish of the Pacific Northwest. Canadian Book Review Annual: 5017.

Colgan, P. 1997. Review of P. Lambert: Sea Cucumbers of British Columbia, Southeast Alaska and Puget Sound. Canadian Book Review Annual: 5020.

Colgan, P. 1997. Review of I. McAlister, K. McAlister, and C. Young: The Great Bear Rainforest: Canada's Forgotten Coast. Canadian Book Review Annual: 5023.

Colgan, P. 1997. Review of W. R. Pollard et al.: Field Identification of Juvenile Salmonids. Canadian Book Review Annual: 5028.

Colgan, P. 1997. Review of B. Hodgrove (*Editor*): The Rat: A Perverse Miscellany. Canadian Book Review Annual: 05029.

Colgan, P. 1997. Review of R. Careless: To Save the Wild Earth. Canadian Book Review Annual: 05037.

Colgan, P. 1997. Review of H. T. Epp (*Editor*): Ecological Reclamation in Canada at Century's Turn. Canadian Book Review Annual: 05038.

Colgan, P. 1997. Review of M. Keating: Canada and the State of the Planet: The Social, Economic, and Environmental Trends that are Shaping our Times. Canadian Book Review Annual: 05039.

Colgan, P. 1997. Review of V. Shiva: Biopiracy: The Plunder of Nature and Knowledge. Canadian Book Review Annual: 5040.

Colgan, P. 1997. Reviews of D. Hodge: Whales; Wild Dogs. Canadian Book Review Annual: 6363, 6364.

Colgan, P. 1997. Reviews of B. Kalman: Why Do Animals Do That? How Animals Communicate? Canadian Book Review Annual: 6368, 6369.

Colgan, P. 1997. Review of P. J. Stoett: The International Politics of Whaling. Canadian Book Review Annual: 5048.

Colgan, P. 1997. Reviews of D. Swanson: Bears; Otters. Canadian Book Review Annual: 6383,6384.

Colgan, P. 1997. Review of C. K. Catchpole and P. J. B. Slater: Bird Song. Canadian Field-Naturalist 111: 348.

Colgan, P. 1997. Review of R. Dawkins: River out of Eden. Canadian Field-Naturalist 111: 354.

Colgan, P. 1998. Review of B. and R. Mearns: The Bird Collectors. Canadian Field-Naturalist 112: 574.

Colgan, P. 1998. Review of T. Wilkins: John Muir: Apostle of Nature. Canadian Field-Naturalist 112: 754.

Colgan, P. 1998. Review of L. Spalding: The Follow: A True Story. Canadian Book Review Annual: 2090.

Colgan, P. 1998. Review of W. Davis: The Clouded Leopard: Travels to Landscapes of Spirit and Desire. Canadian Book Review Annual: 4191.

Colgan, P. 1998. Review of D. Suzuki: Earth Time. Canadian Book Review Annual: 4256.

Colgan, P. 1998. Review of F. Bruemmer: Seals in the Wild. Canadian Book Review: Annual 5002.

Colgan, P. 1998. Review of W. Bush: Ascent of Dogs: Working Dogs in the West. Canadian Book Review Annual: 5004.

Colgan, P. 1998. Review of D. Gilroy: Out and About: Fifty Years of Wildlife Watching. Canadian Book Review Annual: 5014.

Colgan, P. 1998. Review of R. D. Lawrence: Paddy: The Classic story of a Baby Beaver and the Naturalist Who Adopted Him. Canadian Book Review Annual: 5024.

Colgan, P. 1998. Review of R. D. Lawrence: The Place in the Forest. Canadian Book Review Annual: 5025.

Colgan, P. 1998. Review of G. MacEwan: Memory Meadows: Horse Stories from Canada's Past. Canadian Book Review Annual: 5028.

Colgan, P. 1998. Review of G. MacMillan: A Breed Apart: Nova Scotia's Duck Tolling Retriever. Canadian Book Review Annual: 5029.

Colgan, P. 1998. Review of G. Parker: The Eastern Panther: Mighty Cat of the Appalachians. Canadian Book Review Annual: 5030.

Colgan, P. 1998. Review of L. Scanlan: Wild About Horses: Our Timeless Passion for the Horse. Canadian Book Review Annual: 5032.

Colgan, P. 1998. Review of B. Silliker, Jr.: Moose: Giant of the Northern Forest. Canadian Book Review Annual: 5035.

Colgan, P. 1998. Review of K. Van Tighem: Coming West: A Natural History of Home. Canadian Book Review Annual: 5039.

Colgan, P. 1998. Review of G. B.Wiggins: A Cadesfly Family Phryganeidae (Trichoptera). Canadian Book Review Annual: 5040.

Colgan, P. 1998. Review of A. Frizzell and N. H. Pammett: Shades of Green: Environmental Attitudes in Canada and around the World. Canadian Book Review Annual: 5043.

Colgan, P. 1998. Review of M. Harris: Lament for an Ocean: the Collapse of the Atlantic Cod Industry – A True Crime Story. Canadian Book Review Annual: 5048.

Colgan, P. 1998. Review of B. Parfitt: Forest Follies. Canadian Book Review Annual: 5053.

Colgan, P. 1998. Review of J. B. Cruxton: Discovering the Amazon Rainforest: 6365.

Colgan, P. 1998. Review of S. Funston: Animal Smarts. Canadian Book Review Annual: 6369.

Colgan, P. 1998. Review of A. Holden-Boone: Coral Reef. Canadian Book Review Annual: 6375.

Colgan, P. 1998. Reviews of B. Kalman and J. Langille: What are Food Chains and Webs? What is a Life Cycle? Canadian Book Review Annual: 6382, 6383. Review Annual: 5011.

Colgan, P. 1999. Review of R. D. Lawrence: Where the Water Lilies Grow. Canadian Book Review Annual: 5013.

Colgan, P. 1999. Review of C. White: Living off the Sea. Canadian Book Review Annual: 5029.

Colgan, P. 1999. Review of K. Drushka: In the Bight: The B.C. Forest Industry Today. Canadian Book Review Annual: 5038.

Colgan, P. 1999. Review of F. L. Bunnell and J. F. Jonson (*Editors)*: Policy and Practice for Biodiversity in Managed Forests: The Living Dance. Canadian Book Review Annual: 5049.

Colgan, P. 1999. Review of C. Tollefson (*Editor):* The Wealth of Forests: Markets, Regulation, and Sustainable Forestry. 5052.

Colgan, P. 1999. Review of J. Wilson: Talk and Log: Wilderness Politics In British Columbia 1965-1996. Canadian Book Review Annual: 5053.

Colgan, P. 1999. Review of D. M. Hayne (*Editor*): Human Survivability in the 21st Century. Canadian Book Review Annual: 5067.

Colgan, P. 1999. Review of F. Wilson: The Logic and Methodology of Science in Early Modern Thought. Canadian Book Review Annual: 5070.

Colgan, P. 2000. Review of L. Dugatkin: Cheating Monkeys and Citizen Bees. Canadian Field-Naturalist 114: 169.

Colgan, P. 2000. Review of R. Dukas (*Editor)*: Cognitive Ecology. Canadian Field-Naturalist 114: 344-345.

Colgan, P. 2000. Review of A. I. Houston and J. M. McNamara: Methods of Adaptive Behaviour. Canadian Field-Naturalist 114: 541.

Colgan, P. 2000. Review of P. Turchin: Quantitative Analysis of Movement. Canadian Field-Naturalist 114: 547-548.

Colgan, P. 2000. Review of J. Terborgh: Requiem for Nature. Canadian Field-Naturalist 114: 722.

Colgan, P. 2000. Review of A. A. Gilpin and P. Patchet-Goluber: A Guide to Writing in the Sciences. Canadian Book Review Annual: 1016.

Colgan, P. 2000. Review of C. Montgomery: Brood Relations: Animals, Humans, and Politics, Annual Book Review Annual 2139.

Colgan, P. 2000. Review of H. Brody: Seasons of the Arctic. Canadian Book Review Annual: 2171.

Colgan, P. 2000. Review of G. B. Doern and T. Reed (*Editors)*: Risky Business: Canada's Changing Science-based Policy and Regulation Regime. Canadian Book Review Annual: 4061.

Colgan, P. 2000. Review of T. Glavin: The Last Great Sea. Canadian Book Review Annual: 5011.

Colgan, P. 2000. Review of H. Tammemagi: The Waste Crises: Landfills, Incinerators, and the Search for a Sustainable Future. Canadian Book Review Annual: 5042.

Colgan, P. 2000. Review of G. G. Beck and B. Littlejohn (*Editors*): Voices for the Water: Environmental Issues in the Great Lakes – St. Lawrence Drainage Basin. Canadian Book Review Annual: 5043.

Colgan, P. 2000. Review of P. M. Wood: Biodiversity and Democracy: Rethinking Society and Nature. Canadian Book Review Annual: 5045.

Colgan, P. 2000. Review of J. Bachler: Petrotyranny. Canadian Book Review Annual: 5046.

Colgan, P. 2000. Review of A. H. Perera, D. L. Euler, and I. D. Thompson (*Editors*): Ecology of a Managed Terrestrial Landscape: Patterns and Processes of Forest Landscapes in Ontario. Canadian Book Review Annual: 5047.

Colgan, P. 2000. Review of G. Hak: Turning Trees into Dollars: The British Columbia Coastal Lumber Industry 1858-1913. Canadian Book Review Annual: 5048.

Colgan, P. 2000. Review of R. Hayter: Flexible Crossroads: The restructuring of British Columbia's Forest Economy. Canadian Book Review Annual: 5049.

Colgan, P. 2000. Review of B. O'Keefe and J. Macdonald: The Sommers Scandal: The Felling of Trees and Tree Lords. Canadian Book Review Annual: 5051.

Colgan, P. 2000. Review of L. A. Sandberg and P. Clancy: Against the Grain: Foresters and Politics in Nova Scotia, Canadian Book Review Annual: 5052.

Colgan, P. 2000. Review of A. McHughen: Pandora's Picnic Basket: The Potential and Hazards of Genetically Modified Foods. Canadian Book Review Annual: 5062.

Colgan, P. 2000. Review of D. M. Hayne (*Editor*): Governance in the 21st Century: Proceedings of a Symposium held in November 1999 under the auspices of the Royal Society of Canada. Canadian Book Review Annual: 5068.

Colgan, P. 2001. Review of L. Taccon: Biodiversity and Ecological Economics: Participation Values and Resource Management. Biodiversity: Journal of Life on Earth 2(2): 37-38.

Colgan, P. 2001. Review of Atlantic Geoscience Society: The Last Billion Years; a Geological History of the Maritime Provinces of Canada. Canadian Book Review Annual: 5004.

Colgan, P. 2001. Review of A. Gaal: In Search of Ogopogo: Sacred Creature of the Okanagan Waters. Canadian Book Review Review Annual: 5011.

Colgan, P. 2001. Review of W. Grady: The Bone Museum: Travels in the Lost World of Dinosaurs and Birds. Canadian Book Review Annual: 5012.

Colgan, P. 2001. Reviews of T. Hartson: Whales and Other Marine Mammals of British Columbia and Alaska; Whales of Oregon and Other Marine Mammals of Washington and Oregon. Canadian Book Review Annual: 5014, 5015.

Colgan, P. 2001. Review of L. Scanlon: Little Horse of Iron: a Quest for the Canadian Horse. Canadian Book Review Annual: 5023.

Colgan, P. 2001. Review of J. Billinghurst (*Editor*): The Spirit of the Whale: Legend, History, Conservation. Canadian Book Review Annual: 5027.

Colgan, P. 2001. Review of J. Bohlen: Making Waves: The Origins and Future of Greenpeace. Canadian Book Review Annual: 5028.

Colgan, P. 2001. Review of L. Jones (*Editor*): Global Warming: A Guide to the Science. Canadian Book Review Annual: 5029.

Colgan, P. 2001. Review of C. Potvin, M. Kraenzel, and G. Seutin (*Editors*): Protecting Biological Diversity Roles and Responsibilities. Canadian Book Review Annual: 5032.

Colgan, P. 2001. Review of D. Suzuki and H. Dessel: Good News for a Change: Hope for a Troubled Planet. Canadian Book Review Annual: 5033.

Colgan, P. 2001. Review of K. A. Armson: Ontario Forests: A Historical Perspective. Canadian Book Review Annual: 5034.

Colgan, P. 2001. Review of D. Greer: Coming Through Fire: The Wildland Firefighter Experience. Canadian Book Review Annual: 5038.

Colgan, P. 2001. Review of P. W. B. Phillips and R. Wolfe (*Editors*): Govern My Food: Science, Safety, and Trade. Canadian Book Review Annual: 5067,

Colgan, P. 2001. Review of P. Demers (*Editor*): Science and Ethics/La science et l'éthique. Canadian Book Review Annual: 5069.

Colgan, P. 2002. Review of P. S. Chasek: The Global Environment in the Twenty-first Century: Prospects for International Cooperation. Canadian Field-Naturalist 116: 345.

Colgan, P. 2002. Review of J. Perry: Food for Thought: Catholic Insights into Modified Food. Canadian Book Review Annual: 2157.

Colgan, P. 2002. Review of P. Berton: Cats I Have Known and Loved. Canadian Book Review Annual: 5001.

Colgan, P. 2002. Review of N. Eyles: Ontario Rocks: Three Billion Years of Environmental Change. Canadian Book Review Annual: 5005.

Colgan, P. 2002. Review of G. MacEwan: Our Equine Friends: Stories of Horses in History. Canadian Book Review Annual: 5020.

Colgan, P. 2002. Review of R. Orenstein: Survivors in Armor: Turtles, Tortoises, and Terrapins. Canadian Book Review Annual: 5023.

Colgan, P. 2002. Review of J. D. Sept: The Beachcombers Guide to Seashore Life in California. Canadian Book Review Annual: 5027.

Colgan, P. 2002. Review of K. Beazley and J. Boardman: Politics of the Wild: Canada and Endangered Species. Canadian Book Review Annual: 5030.

Colgan, P. 2002. Review of D. L. VanNijnatten and R. Boardman (*Editors*): Canadian Environmental Policy: Context and Cases.Second edition. Canadian Book Review Annual: 5031.

Colgan, P. 2002. Review of J.-P. Hautecoeur (*Editor*): Ecological Education in Everyday Life ALPHA 2000. Canadian Book Review Annual: 5032.

Colgan, P. 2002. Review of J. I. McKenzie: Environmental Politics in Canada: Managing the Commons in the Twenty-first Century. Canadian Book Review Annual: 5035.

Colgan, P. 2002. Review of P. Dearden and R. Rollins (*Editors*): Parks and Protected Areas in Canada: Planning and Management. Canadian Book Review Annual: 5037.

Colgan, P. 2002. Review of M. Howlett (*Editor*): Canadian Forest Policy. Canadian Book Review Annual: 5041.

Colgan, P. 2002. Review of P. Watson: Seal Wars: Twenty-five Years on the Front Lines with the Harp Seals. Canadian Book Review Annual: 5047.

Colgan, P. 2002. Review of C. L. Evans: The War On Weeds. Canadian Book Review Annual: 5050.

Colgan, P. 2002. Review of D. Forsdyke: The Origin of Species Revisited: A Victorian Who Anticipated Modern Developments in Darwin's Theory. Canadian Book Review Annual: 5058.

Colgan, P. 2003. Review of N. Dakin: Complete Encyclopaedia of the Saltwater Aquarium. Canadian Book Review Annual: 1005.

Colgan, P. 2003. Review of M. Bourrie: Hemp: A Short History of the Most Misunderstood Plant and Its Use. Canadian Book Review Annual: 5004.

Colgan, P. 2003. Review of M. de Villiers and S. Hirtle: Sahara: A Natural History. Canadian Book Review Annual: 5009.

Colgan, P. 2003. Review of M. Harris: Waterfalls of Ontario. Canadian Book Review Annual: 5013.

Colgan, P. 2003. Review of J. A. Burnett: A Passion for Wildlife: The History of the Canadian Wildlife Service. Canadian Book Review Annual: 5030.

Colgan, P. 2003. Review of T. H. Fletcher: From Love Canal to Environmental Justice: The Politics of Hazardous Waste on the Canada–U.S. Border. Canadian Book Review Annual: 5032.

Colgan, P. 2003. Review of J. G. Nelson et al. (*Editors*): Protected Areas and Regional Planning Imperative in North America. Canadian Book Review Annual: 5033.

Colgan, P. 2003. Review of Marsha A. Sovada and Ludwig Carbyn: The Swift Fox: Ecology and Conservation of Swift Foxes in a Changing World. Canadian Book Review Annual: 5034.

Colgan, P. 2003. Review of R. Bott, P. Murphy, and R. Udell: Learning from the Forest: A Fifty-year Journey Towards Sustainable Forest Management: 5035.

Colgan, P. 2003. Review of M. de Villiers: Water; The Fate of Our Most Precious Reserve. Canadian Book Review Annual: 5036.

Colgan, P. 2004. Review of H. Lahring: Water and Watershed Plants of the Prairie Provinces. Canadian Book Review Annual: 5006.

Received 17 August 2004
Accepted 6 January 2011

A Tribute to Ian McTaggart-Cowan, 1910-2010, O.C., O.B.C., PhD, LL.D, F.R.S.C.

Rod S. Silver, Neil K. Dawe, Brian M. Starzomski[3], Katherine L. Parker[4], and David W. Nagorsen[5]

[1] Director, The Nature Trust of BC, 4065 Beam Crescent, Victoria, British Columbia V8N 5Y7 Canada
[2] President, Qualicum Institute, A society for ecological, social and economic sustainability, 438 Temple Street, Qualicum Beach, British Columbia V9P 1A3 Canada
[3] Ian McTaggart-Cowan Professor of Biodiversity Conservation and Ecological Restoration, School of Environmental Studies, Social Sciences and Math Building B225, 3800 Finnerty Road, Victoria, British Columbia V8P 5C2 Canada
[4] Ian McTaggart-Cowan Muskwa-Kechika Research Professor, Ecosystem Science and Management Program, University of Northern British Columbia, 3333 University Way, Prince George, British Columbia V2N 4Z9 Canada
[5] Mammalia Biological Consulting, 4268 Metchosin Road, Victoria, British Columbia V9C 3Z4 Canada

Silver, Rod S., Neil K. Dawe, Brian M. Starzomski, Katherine L. Parker, and David W. Nagorsen. 2010. A Tribute to Ian McTaggart-Cowan, 1910-2010, O.C., O.B.C., PhD, LL.D, F.R.S.C. Canadian Field-Naturalist 124(4): 367–383.

When Andy Stewart, a wildlife biologist with the BC Conservation Data Centre, went looking for historical information to include in the final volume of *The Birds of British Columbia*, he found, published in Mackie (1985:114), a letter written by Dr. Rudolph M. Anderson of the Canadian National Museum to naturalist Hamilton Mack Laing. The date was December 26, 1929. In part, it read:

> "There is another factor that enters into the plans. You are now about the only freelance collector in the West who is competent to do museum collecting, and is familiar with the technique, and, as an old apostle, we want you to help pass on some of the tradition to a disciple. We have a young man in view that has been recommended to me from several different sources. His name is Ian McTaggart-Cowan of North Vancouver, now a third year student at the University of BC. I met him at Winson's place in Huntingdon last fall, and Kenneth Racey and Allan Brooks spoke highly of him, also Professors Spencer and MacLean Fraser of the department of zoology at the University.
> …They say his forebears were naturalists, and he has camped and hunted all his life. Spencer says he… is a go-getter in the field. I had only a short conversation with him last fall and was much taken by him…. I think that Cowan is the real thing…."

Ian McTaggart-Cowan was born in Edinburgh, Scotland in 1910 and immigrated to Canada at age three. The eldest of four, he developed an early interest in natural history, which was encouraged by his mother. That interest grew as he did. At age 12, he completed a one-year diary of all the birds he had seen around his North Vancouver home as a requirement for a proficiency badge in the Boy Scouts. Ian would later recall, "James A. Munro unknowingly gave me useful advice at a very early stage in my adventures with birds. In 1923, National Parks of Canada offered a book prize to any boy scout in Canada who achieved his Naturalist badge and submitted a bird diary covering a year of observation. I met the requirements, sent in my diary, and in time received a copy of Gordon Hewitt's book, *The Conservation of Wildlife in Canada.* This was my first introduction to wildlife conservation. I still have the volume, with its congratulation signed by J. B. Harkin, Director of the National Parks of Canada. I was impressed! Some days later a letter came from J. A. Munro, Federal Migratory Bird Officer. He had read my diary and, in a nice way, pointed out some mistaken identifications and fine points not covered in my library of one book (Chester A. Reed's *Bird Guide*). I wrote in reply asking more questions and received helpful answers. Of such small kindnesses new directions are born. Twenty-four years later Munro and I co-authored a book on the avifauna of British Columbia!" (Cowan 1998). Ian's bird diary was the beginning of a life-long obsession with observing, recording and writing about the wonders of the world around him.

While a first-year student at the University of British Columbia, he attended a lecture by Vancouver Natural History Society life member Kenneth Racey, hosted by the Burrard Field Naturalists. The topic was small mammals of the Lower Mainland. Ian was fascinated by Racey's knowledge of wildlife, his understanding of the rapidly changing natural world and his expertise in the use of techniques to study small mammals. Racey invited him to his house to see his collection and, recognizing Ian's enthusiasm, thereafter included him in many of the Racey family field trips, including outings to their summer home at Alta Lake. Racey and Cowan would publish *The Mammals of the Alta Lake Region of Southwestern BC* in 1936.

Ian's first major publication, however, came in 1930 with *The Mammals of Point Grey,* a modest beginning to his over 550 works in print, on radio and on television that followed in the subsequent 80 years.

For Ian, 1930 also saw the beginning of total immersion in the adventures of becoming a vertebrate zoologist. He was appointed as field assistant to Hamilton Mack Laing, a naturalist, outdoor writer and photographer who collected wildlife specimens from Western Canada for the National Museum of Canada. Ian first worked for a month on the little known Tobacco Plains near Elko, British Columbia, then for three months in the Rocky Mountain National Parks of Jasper and Banff. It is here that Ian's initial biological studies of the fauna of the parks began.

The following year, Laing's expedition was cancelled as the depths of the Great Depression took hold and research monies vanished. Kenneth Racey was seriously ill in the winter of 1930–31, and in the spring, decided to take a few months away from his business to recuperate. He asked Ian to accompany him on an extended field trip. They spent May 1931 studying the birds and mammals in the Tofino area of Vancouver Island including the fascinating near-shore fauna, and the alpine assembly of creatures at the head of the Nanaimo River. The most important contribution of the Nanaimo River work was the rediscovery of the Vancouver Island Marmot, an animal not seen since 1911, when the type series was collected on the mountains above Port Alberni by an expedition from the Museum of Vertebrate Zoology, Berkeley. June was spent with the entire Racey family on Anarchist Mountain and in other locations in the southern Okanagan where a new mammal for British Columbia was discovered: the Pacific Pallid Bat. The expedition continued in July and August in the western Chilcotin and included a side trip by Racey into the unique "northern" habitats of the Itcha Mountains to see caribou. Ian acknowledged the extraordinary contribution that Racey made to his growth and understanding of wild landscapes and their vertebrates. Though a generation apart, Kenneth Racey became a life-long friend and in 1936, Ian's father-in-law.

In 1932, after graduating from the University of British Columbia with an undergraduate degree, Ian took a teaching fellowship at the University of California at Berkeley to begin his doctorate. There he had the opportunity to work under the guidance of noted ecologist Joseph Grinnell. While at home in British Columbia during the summer of 1933, a broken leg almost ended his doctoral studies because he was unable to report for duties as a teaching assistant. He found himself without an income to pay for fees and books for the autumn term. His year was saved by the generosity of Grinnell who accompanied his gift to Ian with some scholarly advice: "Now, no more foolishness about dropping out of your program because of a small shortfall. I don't want the money back—give it to some worthy student somewhere down your path. There will be many of them." Ian fondly remembers Grinnell for his kindness, and for providing a first glimpse of the dedication that good thesis advisors require in order to ensure the success of their graduate students.

Ian completed his doctorate at Berkeley in 1935. His doctoral thesis was on geographic variation and taxonomy of the mule and white-tailed deer genus, *Odocoileus,* of western North America. It was probably the first published document to include statistical treatment of big mammals, written at a time when the Canadian government still believed that game was unlimited and all predators should be shot. Ian returned to British Columbia to work as the first university-trained biologist at the Provincial Museum in Victoria, then directed by Francis Kermode. As Corley-Smith (1989) noted, "Cowan had taken his training in the Museum of Vertebrate Zoology at Berkeley, at the time 'one of the great institutions of the world in terms of systematic collections. Even though the collections had been neglected, there was good basis for a fresh start' and Ian went about the task of reversing the years of neglect."

Cowan would recall, "my analysis of the situation was that, apart from cataloguing and curating the collections, the Museum's most important opportunity was in getting out into the province and studying the great diversity of living animals and plants to be found there."

Ian seized on that opportunity and initiated a series of systematic surveys of the vertebrates in different regions of the province through his own fieldwork and a network of naturalists and museum collectors. Possibly the most ambitious was a 3-year survey of the vertebrates on the remote coastal islands of the central-northern coast with Thomas McCabe, mostly sampled by fish boat. This tradition of biodiversity surveys by the Museum would carry on for many decades.

During his five years at the Museum, Cowan published more that 20 scientific papers, some through the Museum, and others in various scientific journals. In 1939, he initiated the Provincial Museum's Occasional Papers series with his monograph "The Vertebrate Fauna of the Peace River District of British Columbia". The series ran for 50 years with 26 Occasional Papers produced that covered various aspects of the province's natural history.

In 1940, he left the Museum for an appointment as Assistant Professor in the Department of Zoology, University of British Columbia, in Vancouver, but continued to work closely with Museum staff to collect, classify and describe the province's diverse fauna. Among the most successful collaborative projects was the publication of *The Mammals of British Columbia* in 1956 with close friend, former graduate student, and colleague Charlie Guiguet. In the following 22 years, this important reference book had seven printings and two

FIGURE 1. Ian McTaggart Cowan, October 2004 as Director Emeritus of the Nature Trust of British Columbia (Andrew Klaver, Nature Trust of British Columbia).

minor revisions and was one of the most widely used and widely distributed handbooks the museum had ever published.

Ian appeared on the university scene at a most fortuitous time. The great graduate schools in the United States had discovered "ecology", and the graduates, of whom Ian was one, were making waves. The "field" sciences were in ferment.

In 1943, Ian was contracted by Parks Canada to undertake the first extensive field studies of the fauna of the Rocky Mountain Parks of Canada. He was a natural choice for the work because, through his three-month stint in the parks with Mack Laing 13 years earlier, he was immediately at home in the landscape. His first guide was the legendary mountain man, James "Jimmy" Simpson, who provided safe passage to the most remote areas of the Rockies. "Jimmy taught me everything I couldn't get from books," said Ian in a 2005 interview with Briony Penn. "We climbed as high up every mountain as we could get, then would stop and use our field glasses to count, age and sex the animals as best we could. You never disturbed those animals, because if you did they'd get all mixed up, and forget it — your study is over."

Promoted to Professor of Zoology at UBC in 1945, he served as head of the department from 1953 to 1964. During this time he continued to develop and teach courses in vertebrate zoology. It was the first academic program in Canada to emphasize the biological basis of wildlife conservation. As well, Cowan was largely responsible for convincing Canadian governments to recruit trained wildlife biologists to staff their wildlife management agencies. He himself served as a scientific advisor to the BC Game Commission.

Ian was a prolific researcher and writer, achieving an impressive number of published scientific works. The scope of his efforts is unprecedented with work on both invertebrates and vertebrates. His papers on mammals ranged from shrews to whales, a scope unimaginable in today's world of specialization. However, his scientific papers made important contributions in other areas as well, such as the now neglected field of vertebrate taxonomy. His taxonomic revisions of the mule and white-tailed deer (1936), mountain sheep (1940), pikas (1954), and coastal populations of the deer mouse (1945) are important works still cited today and used as models for testing with the latest modern genetic methods.

The vertebrate zoology program at UBC was established around the personal specimen collections belonging to Ian and friend Kenneth Racey. Those collections are part of the over 40 000 specimens known as the Cowan Vertebrate Museum, now part of the Beaty Biodiversity Museum at the University of British Columbia.

The 60s and early 70s were exciting times for students in the field sciences at UBC. In addition to Cowan and Mary Taylor in the zoology department, Ian's students often drew on the vast knowledge and guidance of top notch leaders in related disciplines such as Bert Brink in plant science, A. J. Wood in animal science, D. J. Laird in soil science, Vladimir Krajina and Kay Beamish in botany, Bill Matthews in geology, a young Fred Bunnell in forestry/wildlife and Peter Larkin and Bill Hoar in fisheries. McTaggart-Cowan's extensive bibliography clearly demonstrates his collaborative approach to exploring the many fascinating aspects of science.

FIGURE 2. Ian with Black-tailed Deer, Constitution Hill, Vancouver Island, 1939 (Image B-01601 Courtesy of the Royal British Columbia Museum Archives) .

Ian became Dean of Graduate Studies at UBC in 1964. Even with expanded responsibilities, he continued to teach a course in wildlife biology, supervise directed studies and guide the research of zoology doctoral candidates. "You would be surprised how much work you can get done in the quiet of 2 hours before the world wakes up," he told Rod Silver, explaining his habit of rising early to keep up with his interests.

Education was at the heart of McTaggart-Cowan's long career and he was phenomenally successful in influencing people, from politicians to children. He was an engaging and much sought after speaker. The key to teaching, he said, was to "identify the point where the audience will join you and engage themselves, even if they think you are wrong. Dogmatism turns people

off. I tried to paint a picture of what a fascinating and dramatic world we live in. I like to explain to people the beautiful, fascinating things that I see. All my life I have tried to explain to colleagues, family, students, anyone who will listen to me, what a beautiful place I am looking at! It is not all sweetness and light, but this world is absolutely fascinating" (Penn 2005).

In all, Ian worked with over 100 graduate students and directly supervised a wide variety of research by some 23 PhD and 20 Masters students. Perhaps Carl Linnaeus, the father of taxonomy said it best: "a professor can never better distinguish himself in his work than by encouraging a clever pupil, for the true discoverers are among them, as comets amongst the stars."

Some of his graduate students were indeed the new "comets" in the wildlife field. Names like Maurice Hornocker (mountain lions), Valerius Geist (mountain sheep), Charles Jonkel (bears), Fred Zwickel (Blue Grouse), and C.S. "Buzz" Holling (predation) quickly became associated with excellence in wildlife science in academic circles.

Geist recalls, "I knew Dr. Cowan as an intellect who quickly grasped unusual, new, complex concepts and appreciated such even if they ran afoul of conventional social norms. Homosexuality in mountain sheep was one such example. Realization that growth, development and bioenergetics were vital aspects in understanding mammals was another."

Other students such as Ian Stirling, Daryll Hebert, Dave Hatler, Steve Johnson, Charles Guiguet, Yorke Edwards, James Hatter, J. Bristol Foster and many others enjoyed equally successful careers in government and consulting.

Former student Dave Hatler no doubt spoke for students and colleagues alike in the dedication of his latest book:

> "To Ian McTaggart-Cowan, an extraordinary naturalist, remarkable biologist and as good a mentor as anyone could hope for" (Hatler et al. 2008).

It is difficult to imagine any areas of terrestrial vertebrate zoology and wildlife conservation that have not been influenced by Ian's work. Long-time UBC contemporary and colleague, the late Bert Brink, agreed: "More than any others, Ian and his students have fostered knowledge of the fauna of the land and sea. I would stand by this choice (from the multitude of his accomplishments) as the most far reaching and significant: his field work was outstanding and global."

Indeed, Ian identified 15 new subspecies of vertebrates, and while in Australia he rediscovered the Mountain Pygmy-Possum that was previously known only from fossils (Campbell et al., in preparation).

It is little wonder then that Ian was often referred to as the "Dean of Vertebrate Zoologists" in Canada.

Few know of the pivotal role that Ian played in the elimination of the bounty system in Canada. Beginning

FIGURE 3. Ian with vertebrate skull collection at University of British Columbia, 1951 (University of British Columbia Archives).

in the 1920s, the provinces had systems to reward those who would rid the land of "undesirable" animals or so-called vermin. Some rewards involved cash, some involved gun cartridges. The systems were costly, inefficient and open to widespread abuse. Wolves, cougars, coyotes, Bald Eagles, Golden Eagles, crows, jays and magpies were among the wildlife on the bounty lists. Together with J.R. Dymond, a top Canadian fisheries biologist at the University of Toronto, and armed with good data from both Canada and the United States, they lectured on the folly of the bounty system to hundreds of audiences over nearly 10 years. In the end they prevailed, obtaining strong support from the hunting community. Ian would later recall this victory as "an important step in trying to put scientific management of wildlife into play." By 1973, all Canadian jurisdictions but the Northwest Territories had eliminated the bounty system on wildlife. [Saskatchewan and Nova Scotia have recently implemented limited bounty programs].

Cowan's interests in large mammals and ecology led him to extensive field studies in the Canadian Arctic, the Rocky Mountain National Parks, western Mexico, Scotland, Finland, Africa, Australia, several Pacific Islands and throughout British Columbia. Long before there were computers with electronic search engines, he was highly sought after as an expert advisor on a variety of nature and other issues. In all, his 36 years of formal conservation studies took him to six continents and resulted in over 275 technical and popular publications, being co-author of six teaching films on mammalian behaviour, 110 educational television programs, some 200 radio programs and countless public lectures.

Ian is recognized as a pioneer in the use of television as a medium to provide information to educate the public about conservation and the wonders of the

natural world. The *Fur and Feathers* series and *The Living Sea* series, both produced by the Canadian Broadcasting Corporation (CBC), went to air live. Only *The Web of Life* series, also a CBC production, was taped.

In the popular *Fur and Feathers* series of 52 episodes in 1955–56, the approach was to confront a youngster with a natural history object that had never been seen before, and provide facts by responding to the child's questions.

The *Web of Life* was aired during 1960–63 and used footage from British Columbia, Uganda, southern United States, the Arctic, the Caribbean, and the Gulf of Mexico. In 1963, one of the shows in that series won an award for educational television films at an international television festival.

Although Ian formally "retired" from the University of British Columbia in 1975, his varied interests kept him active on many fronts. One special scientific project involved the consolidation of information on the distribution, abundance and other aspects of the ecology of the bird fauna of British Columbia. It was a sequel to his work with James A. Munro some 40 years earlier. This time though, Ian and the other authors wrote species accounts based on a database of nearly 2 million records contributed by over 11 000 volunteers and a bibliography of almost 4700 articles.

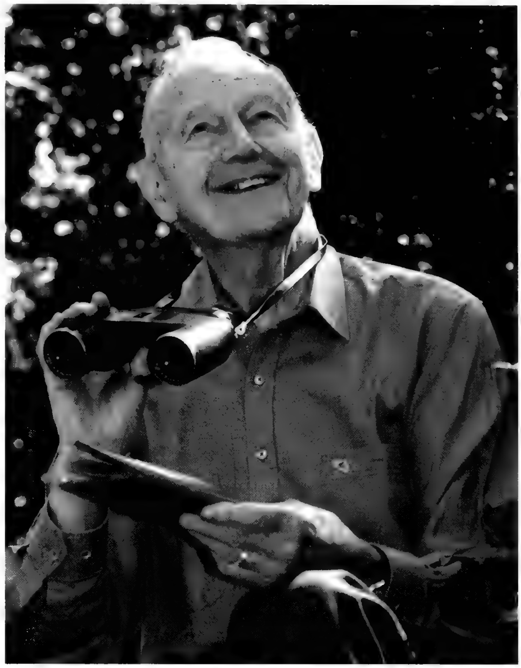


FIGURE 4. Ian birding in his yard and celebrating the release of the 4th and final volume of the *Birds of British Columbia,* 2001 (Debra Brash/Victoria Times Colonist).

Ian made an exceptional contribution to that long-term project, *The Birds of British Columbia*. His efforts to help initiate the BC Nest Record Scheme that provided vital historical data for the work and his role as one of the authors are well chronicled in the four-volume set. Throughout the more than 20-year term of the project, Ian took on the usual tasks of analyzing data, writing species accounts, and proofing the galleys.

The summarization of the data for Volumes I and II was formidable, each author dealing with the information on thousands of cards that were tabulated manually. The accounts were written in long hand and then turned over to staff at the Canadian Wildlife Service and their word-processing skills.

By the time the authors began Volume III, the personal computer had appeared and they chose to make use of this new technology to help prepare the last two volumes. This meant Ian had to learn the basics of operating a computer along with the database and word-processing programs they used to summarize the data and write the species accounts, all of which he did proficiently. He was 82 years of age.

In addition to his author's duties, at the request of the federal and provincial governments, Ian also served for 10 years as the volunteer Chair and project manager for the production of Volumes III and IV.

Managing the activities of the six other authors plus reporting to the federal and provincial Wildlife Directors was a complex and sometimes thankless task. But his leadership paid handsome dividends. Not only were Volumes III and IV of the Birds of British Columbia produced in a timely fashion, they provided the same type of comprehensive data that made the first two volumes so valuable and popular. For Volume IV, Ian also wrote more species accounts than any other author as well as being the lead author of the 46-page synopsis, the latter in his 90th year. Volume IV was shortlisted for the 2002 Roderick Haig-Brown Regional British Columbia Book Prize.

As Neil Dawe, a co-author of *The Birds of British Columbia* noted "I had the good fortune to work with Ian on the project and saw the breadth of his knowledge, far beyond the biological realm, and his significant administrative abilities firsthand. What stuck with me the most, however, was his youthful approach to life and his respectfulness of others no matter their status in life. Ian was always open to new experiences, such as learning to operate a computer in his early 80s. And new ideas, however unorthodox, were always welcome, indeed encouraged. While he did not necessarily agree with the new concepts, he weighed them carefully, and respectfully challenged them when necessary. His challenges always made one think more carefully and ultimately an improved approach to the issue at hand was the result."

Author/naturalist Bruce Whittington asked Ian in 2001 about his last recorded bird observation. "This morning – a juvenile Cooper's hawk appeared again in the garden. It's banded", Ian said "but I haven't got the number. Not yet, but I will!" At 92, the habits of a scientist were still very much a part of his every day life.

FIGURE 5. The annual *Birds of British Columbia* "Authors get-together" at the home of Dr. Ian McTaggart-Cowan (seated), 12 April 2010. Standing, from left, Gary W. Kaiser, Neil K. Dawe, Andrew C. Stewart, Michael C.E. McNall, and John M. Cooper (missing: R. W. Campbell). Photo by Brenda Beckstrom.

In the words of long-time friend and colleague, Tom Beck, "even in his 90s, Ian never lost his school-boy enthusiasm for nature".

Ian admitted to being a dedicated collector and museums in several parts of the world now house his collected treasures. His early collections included mammal, bird and plant specimens and the literature of wildlife in the northwest. Later, he focused on kodachrome transparencies, alpine plants, rhododendrons, special ground orchids and award-winning revenue stamps and their legal documents. Always the collections were in search of more information on a topic of interest. The search continued until his death. His learning never stopped.

Ian and his wife Joyce were devoted companions for over 70 years until her passing in 2002. They raised two children, Garry and Ann. Garry (PhD, UBC 1969), a talented fisheries biologist in his own right, was a respected researcher/lecturer at Memorial University, Newfoundland, and coauthored several papers with his father, including the naming of a new species of chiton in 1977. Garry died in 1997. Ann holds a BSc. from UBC (Microbiology/Biology, 1961) and a Masters degree in Canadian Studies (Carleton University, 1964). She is an accomplished pianist and composer. She fondly remembers Ian as a generous and caring husband and father with an enduring sense of humour, extraordinary zeal for exploring the world and a habit, in his latter years, of relaxing with his Hohner Echo harmonica. She also remembers him as a bit of an adventurer who annually navigated his open 6-metre runabout the 30 or so kilometres across the Straight of Georgia from Vancouver to the family's summer stomping grounds on Saturna Island. Three grandchildren and five great grandchildren have benefited from his wisdom and guidance.

Together, Ian and Joyce savoured many of the treasured wild spots of six continents including some 30 trips as invited naturalist hosts, educating guests on Sven Lindblad's ecotourism cruises for Special Expeditions. On early field trips, Joyce paid special attention to data on the occurrence of vegetation, later becoming an expert gardener. A keen and knowledgeable bird observer for all of her life, she kept daily diaries of the visitors to her feeders at their Victoria home. She was, after all, Kenneth Racey's daughter, and natural history was a big part of daily life. Back in the early 1930s, apparently there was more than a small mammal collection that caught Ian's eye in the Racey household.

When Ian was 95, writer Briony Penn asked him about his recipe for living to a good old age:

> "Choose your parents very carefully," he said; "find yourself an excellent partner — you can't do it all on your own; eat lots of venison, which you have to get yourself, so you have to climb mountains so you get lots of exercise. And last, but not least, maintain enthusiasm. Enthusiasm is a self-feedback system."

Ian passed away peacefully on 18 April 2010 surrounded by his family in his Saanich home. He was 2 months shy of his 100th birthday.

Looking back, it was naturalists like Racey and Laing who fed and encouraged Ian's seemingly insatiable initial curiosity of the outdoors. And mentors and contemporaries such as Grinnell, A. Starker Leopold, Dymond, Guiguet and the many other colleagues and students who worked with Ian helped fuel his enthusiasm for exploring the science of that world.

When asked what it is that connected him so passionately to the natural world he said:

> "I find it emotionally very satisfying. I think if you spend part of your life alone out in the wild, you are changed. You have a chance to really experience the extraordinary wealth of the creatures around you, and get a heightened sense of imagination and sensitivity to a living community. It doesn't mean that you can't cut a tree or eat a venison steak, it is just understanding the role of each of our lives and how we all fit in" (Penn 2005).

That sensitivity to a living community led to an exceptional career in conservation biology and his passion for sharing information led to equally important contributions to education. His lengthy listing of works, awards, distinctions and public service reflects a broad spectrum of interests, and is a testament to his unsurpassed contributions to Canada.

Ian spent his entire life as a learner and educator, the true mark of a Renaissance Man. In his own words, "Evolution is never finished and this applies equally to ideas and to organisms." He never ceased to evolve —as a naturalist, scientist, writer, collector and human being.

Yes, Cowan was indeed, "the real thing."

Awards and Distinctions

Ian received more awards and distinctions than virtually any other Canadian scientist. These include the Canadian Centennial Medal (1964); the Leopold Medal of the Wildlife Society (1970); Einarsen Award in Conservation by the Northwest Section of the Wildlife Society (1970); Officer of the Order of Canada (1972); Fry Medal of the Canadian Society of Zoologists (1975); Queen Elizabeth Silver Jubilee Medal (1977); the J. Dewey Soper Award (1982, Alberta Society of Professional Biologists); International Conservationist of the Year (1985, American Wildlife Society); Outstanding Achievement Award (1990, Foundation for North American Wild Sheep); Officer of the Order of British Columbia (1991); Doris Huestus Spiers award for Lifetime Achievement (1998, Canadian Society of Ornithologists); and the Ted Barsby Award for Conservationist of the Year (2000, BC Wildlife Federation).

He was an Honorary Life Member and one-time President of the Wildlife Society (1955), Honorary Life Member and Part President of the Pacific Science Association (1964), Honorary Life Member of the Alberta Society of Professional Biologists (1982) and Association of Professional Biologists of British Columbia (1984), and invited Fellow of the Royal Society of Canada (1946), Fellow of the Arctic Institute of North America (1955), Fellow of the American Association of Advancement of Science (1955), Fellow of the California Academy of Sciences (1955) and an Erskine Fellow (1969, University of Canterbury).

Ian was also, for many years, Honourary President of BC Nature (Federation of British Columbia Naturalists) and Honourary Curator and Research Associate of the Royal BC Museum.

In recognition of his outstanding achievements, he was awarded a Doctor of Environmental Studies by the University of Waterloo (1976), honorary D.Sc. degrees by the University of British Columbia (1977), the University of Victoria (1985) and the University of Northern British Columbia (1997) and LL.D degrees by the University of Alberta (1971) and Simon Fraser University (1981).

In 1988, the Association of Professional Biologists of British Columbia established the Ian McTaggart-Cowan Award of Excellence in Biology to recognize members who have made outstanding contributions to biology. Former student Daryll Hebert and Birds of BC co-authors Wayne Campbell and Neil Dawe are among the nine recipients to date.

Ian's name is associated with three permanent post-secondary scholarships to assist students in his discipline: The Ian and Joyce McTaggart-Cowan Scholarship at the University of Victoria for outstanding students proceeding to year 3 or 4 of an Honours program in Biology, the Dr. Ian McTaggart-Cowan Scholarship in Environmental Studies for University of Victoria graduate students in the School of Environmental Studies who are focusing on Endangered Species Recovery and/or Ecological Restoration, and the Ian McTaggart-Cowan Scholarship in Wildlife Management at the University of Northern British Columbia.

In addition, the University of Northern British Columbia created the Ian McTaggart-Cowan Muskwa-Kechika Research Chair (2000) and the University of Victoria established the Ian McTaggart-Cowan Professor of Biodiversity Conservation and Ecological Restoration in its School of Environmental Studies (2005).

The University of Victoria has also named a student residence at its Commonwealth Village in his honour. And in 1992, Ian donated to the University of Northern BC, over 2000 titles from his personal natural history library.

Fittingly, Ian also had an invertebrate species and vertebrate subspecies named in his honour: *Cuspidaria cowani*, a septibranch bivalve and *Microtus townsendii cowani*, the Triangle Island subspecies of Townsend's Vole.

Public Service

Ian had an outstanding record of public service. As a founding member, he served for seven years (1955–1962) on the National Research Council of Canada where he was the first Chairman of the Advisory Committee on Wildlife Research. He also served on the Fisheries Research Board of Canada (1954–1965). He was a member and one time Chair of the BC Resources Council (1949–1960), President of the Biological Council of Canada (1966–1968), Chair of the Canadian Environmental Advisory Council (1975–1979), member of the Environmental Protection Board, member of the Arctic Gas Pipeline Board (1973–1976), member of the Arctic Environmental Council (1974–1976), Chair of the Canadian Committee on Whales and Whaling (1978), and inaugural Chair of the Public Advisory Board of the BC Habitat Conservation Trust Fund (1981). Ian was also active with the City of Vancouver Museum Board (1959–1962), Friends of the Royal BC Museum (1991), a founding director (1971–2002) and Director Emeritus (2002–2010) of The Nature Trust of British Columbia. Ian served as a member of the University of British Columbia Senate for 21 years, Chancellor of the University of Victoria from 1979 to 1984 and was the first Chair of the Academic Council of BC for six years (1976-1982).

Internationally, he was Chair of the Board of Governors of the Arctic Institute of North America (1955); President of the Wildlife Society (1955); Vice President of the International Union for the Conservation of Nature; a member of the Select Committee on National Parks for the United States Secretary of the Interior (1966-1968); Visiting Scientist, CSIRO, Wildlife Division, Canberra Australia (1969-1970); and Chair, National Research Council of the United States Special Committee on Grizzly Bear Conservation in Yellowstone National Park (1973-1974).

Acknowledgments

For details and helpful comments, we thank the late Bert Brink, Valerius Geist, the Habitat Conservation Trust Foundation, Daryll Hebert, Charles Krebs, Bill Merilees, The Nature Trust of British Columbia, Ann Schau and Andy Stewart. The production of the extensive bibliography was greatly assisted by Dennis Demarchi, C. Rollins and Ann Schau.

Literature Cited

Campbell, R. W., D. A. Demarchi, and **R. D. Jakimchuk.** *In preparation.* Ian McTaggart Cowan—an enduring legacy of biology, conservation and wildlife management (Celebrating 100 Years with 100 Memories), Biodiversity Centre for Wildlife Studies, Victoria British Columbia.

Corley-Smith, P. 1989. White bears and other curiosities. The first 100 years of the Royal British Columbia Museum. Royal British Columbia Museum, Victoria. 148 pages.

Cowan, I. McT. 1998. Moments from the education of an ornithologist. The Doris Huestus Spiers Lecture, *Picoides* 11(2): 17-22.

Hatler, D. F., D. W. Nagorsen, and **A. M. Beale.** 2008. The carnivores of British Columbia. Royal BC Museum Handbook, Volume 5, Mammals of British Columbia. 371 pages.

Mackie, R. 1985. Hamilton Mack Laing: hunter-naturalist. Sono Nis Press, 234 pages.

Penn, B. 2005. The natural history of Ian McTaggart-Cowan. Focus Magazine, Victoria 04-01.

Silver, R. S. 2004. Renaissance man. Discovery—A Journal of the Vancouver Natural History Society, Spring.

Whittington, B. 2001. Ian McTaggart-Cowan—for the birds. Victoria Times Colonist, 12 August page D8.

22 November 2010

Bibliography of Ian McTaggart-Cowan

Cowan, I. McT. 1929. Note on Yellow-Bellied Marmot. The Murrelet 10: 64.

Cowan, I. McT. 1930. Mammals of Point Grey. The Canadian Field-Naturalist 44(6): 133–134.

Cowan, I. McT. 1930. Notes on some mammals in British Columbia. The Canadian Field-Naturalist 44: 207.

Cowan, I. McT. 1932. The ecology and life history of the Columbian black-tailed deer, *Odocoileus columbianus columbianus,* (Richardson) in British Columbia. A Thesis submitted for the degree of Bachelor of Arts in the Department of Zoology, The University of British Columbia, 98 pages.

Cowan, I. McT. 1933. Some notes on the hibernation of *Lasionycteris noctivagans*. The Canadian Field-Naturalist 48: 74–75.

Cowan, I. McT. 1933. The British Columbia woodchuck *Marmota monax petrensis*. The Canadian Field-Naturalist 47: 57.

Cowan, I. McT. 1933. The mule deer of southern California and northern lower California as a recognizable race. Journal of Mammalogy 14: 326–327.

Cowan, I. McT. 1933. A new race of deer from eastern California. Proceedings of the Biological Society of Washington 46: 67–70.

Cowan, I. McT. 1934. Two cases of pathologic skin growths in deer of the genus *Odocoileus.* The Murrelet 15: 81–82.

Cowan, I. McT. 1935. A distributional study of the *Peromyscus sitkensis* group of white-footed mice. University of California Publications in Zoology 40: 429–438.

Cowan, I. McT. 1935. Distribution and variation in deer (Genus *Odocoileus*) of the Pacific coastal region of North America. University of California, PhD thesis, 338 pages.

Cowan, I. McT. 1936. Notes on some mammals in the British Columbia Provincial Museum with a list of the type specimens of North American recent mammals in the museum. Canadian Field-Naturalist 50: 145–148.

Cowan, I. McT. 1936. A review of the reptiles and amphibians of British Columbia. British Columbia Museum, 25 pages.

Cowan, I. McT. 1936. Nesting habits of the flying squirrel, *Glaucomys sabrinus*. Journal of Mammalogy 17: 58–60.

Cowan, I. McT. 1936. Distribution and variation in deer (genus *Odocoileus*) of the Pacific coastal region of North America. California Fish and Game 22: 155–246.

Racey, K., and **I. McT. Cowan.** 1936. Mammals of the Alta Lake Region of south-western British Columbia. *In* Report of the Provincial Museum. 1935 pages. H15–H29 British Columbia Provincial Museum, Victoria.

Cowan, I. McT. 1937. Additional breeding colonies of the Herring Gull in British Columbia. Murrelet 18(1–2): 28.

Cowan, I. McT. 1937. The distribution of flying squirrels in western British Columbia with the description of a new race. Proceedings of the Biological Society of Washington 50: 77–82.

Cowan, I. McT. 1937. A review of the reptiles and amphibians of British Columbia. Pages 16–25 in Report of the Provincial Museum for 1936, Victoria, British Columbia.

Cowan, I. McT. 1937. The house finch at Victoria British Columbia. Condor 39: 225.

Cowan, I. McT. 1937. A new race of *Peromyscus maniculatus* from British Columbia. Proceedings of the Biological Society of Washington 50: 215–216.

Cowan, I. McT. 1938. Distribution of turtles in coastal British Columbia. Copeia 1938(2): 91.

Cowan, I. McT. 1938. Distribution of the races of the Williamson Sapsucker in British Columbia. Condor 40(3): 128–129.

Cowan, I. McT. 1938. Geographic distribution of colour phases of the red fox and black bear in the Pacific Northwest. Journal of Mammalogy 19: 202–206.

Cowan, I. McT. 1938. Nature's children in our western gardens. The Garden Beautiful 7(5): 6–8.

Cowan, I. McT. 1938. Notes on the hares of British Columbia with the description of a new race. Journal of Mammalogy 19: 240–243.

Cowan, I. McT. 1938. The fur trade and the fur cycle: 1825–1857. British Columbia Historical Quarterly: 19–30.

Cowan, I. McT. 1938. What causes freak antlers? Angler and Hunter Outdoor Magazine. 3 pages.

Cowan, I. McT. 1938. White-tailed Ptarmigan of Vancouver Island. Condor 41: 82–83.

Cowan, I. McT. 1938. Some fish records from the coast of British Columbia. Copeia 1938(2): 97.

Cowan, I. McT. 1939. Black Phoebe in British Columbia. Condor 41: 123.

Cowan, I. McT. 1939. The sharp-headed finner whale of the eastern Pacific. Journal of Mammalogy 20: 215–225.

Cowan, I. McT. 1939. The vertebrate fauna of the Peace River District of British Columbia. Occasional Papers of the British Columbia Provincial Museum, 1: 1-102.

Cowan, I. McT. 1940. Distribution and variation in the native sheep of North America. American Midland Naturalist 24: 505–580.

Cowan, I. McT. 1940. Bird records from British Columbia. Murrelet 21: 69–70.

Cowan, I. McT. 1940. Two apparently fatal grouse diseases. Journal of Wildlife Management 4: 311–312.

Cowan, I. McT. 1940. Winter occurrence of summer birds on Vancouver Island, British Columbia. Condor 42: 213–214.

Cowan, I. McT. 1940. Pentadactyly in a Spotted Sandpiper. The Murrelet 21: 6.

Cowan, I. McT. 1941. Insularity in the genus *Sorex* on the north coast of British Columbia. Proceedings of the Biological Society of Washington 54: 95–108.

Cowan, I. McT., and **J. Hatter.** 1940. Two mammals new to the known fauna of British Columbia. The Murrelet 21: 9.

Cowan, I. McT. 1941. Fossil and subfossil mammals from the Quaternary of British Columbia. Transactions of the Royal Society of Canada 35: 39–50.

Cowan, I. McT. 1941. Longevity of the red-legged frog. Copeia 1941(1): 48.

Cowan, I. McT. 1942. Notes on winter occurrence of bats in British Columbia. The Murrelet 23: 2.

Cowan, I. McT. 1942. Food habits of the Barn Owl in British Columbia. The Murrelet 23(2): 48–53.

Cowan, I. McT. 1942. Report upon some diseases and parasites of game birds and fur-bearing mammals in British Columbia. British Columbia Provincial Game Commission, 6 pages.

Cowan, I. McT. 1942. Economic status of the pheasant on the cultivated lands of the Okanagan Valley. BC Annual Report of the British Columbia Game Commission: 49–62.

Cowan, I. McT. 1942. Some diseases and parasites of game birds and fur-bearing mammals in British Columbia. Pages K40–K45 *in* Annual Report of the British Columbia Game Commission for 1941. Victoria, British Columbia.

Cowan, I. McT. 1942. Termite-eating by birds in British Columbia. The Auk 59(3): 451.

Cowan, I. McT. 1943. Aspergillosis in a Thayer Gull. The Murrelet 24(2): 29.

Cowan, I. McT. 1943. Notes on the life history and morphology of the *Cephenemyia jellisoni* (Townsend) and *Lipoptena depressa* (Say), two dipterous parasites of the Columbia black-tailed deer (*Odocoileus hemionus columbianus* (Richardson). Canadian Journal of Research D21: 171–187.

Cowan, I. McT. 1943. Report on game conditions in Banff, Jasper and Kootenay national parks. Canadian Wildlife Service Report C313, Ottawa. Ontario.

Cowan, I. McT. 1944. Further notes on the winter occurrence of bats in British Columbia. The Murrelet 25: 2

Cowan, I. McT. 1944. The House Finch (*Carpodacus mexicanus*) in Alberta. The Murrelet 25(3): 45.

Cowan, I. McT. 1944. The Dall porpoise, *Phocoenoides dalli* (True), of the northern Pacific Ocean. Journal of Mammalogy 25: 205–306.

Cowan, I. McT. 1944. Parasites, diseases and injuries of game animals in Banff, Jasper, and Kootenay National Parks. National Parks Bureau, 48 pages..

Cowan, I. McT., and **C. D. Fowle.** 1944. Visceral gout in a wild Ruffed Grouse. Journal of Wildlife Management 8(3): 260–261.

Munro, J. A., and **I. McT. Cowan.** 1944. Preliminary report on the birds and mammals of Kootenay National Park, British Columbia. The Canadian Field-Naturalist 58: 34–51.

Syverton, J. T., and **I. McT.Cowan.**1944. Bird pox in the Sooty Grouse *Dendragapus fuliginosus fuliginosus* with recovery of the virus. American Journal of Veterinary Research 16: 215–222.

Cowan, I. McT., and **J. A. Munro.** 1944–45. Birds and mammals of Revelstoke National Park (Part1). Canadian Alpine Journal 29: 1: 100–121.

Cowan, I. McT. 1945. The free-tailed bat, *Tadarida macrotis* in British Columbia. The Canadian Field-Naturalist 59: 149.

Cowan, I. McT. 1945. A beaked whale stranded on the coast of British Columbia. Journal of Mammalogy 26: 93–94.

Cowan, I. McT. 1945. The ecological relationships of the food of the Columbian black-tailed deer, *Odocoileus hem-*

ionus columbianus (Richardson), in the coast forest region of southern Vancouver Island, British Columbia. Ecological Monographs 15: 109–139.

Cowan, I. McT. 1945. Report of wildlife studies in the Rocky Mountain parks in 1945. Mimeographed report, National Parks Bureau, 34 pages.

Cowan, I. McT. 1945 Standing room only — there's plenty of wildlife in Jasper. Canadian National Magazine, September.

Cowan, I. McT., and **G. C. Carl.** 1945. The northern elephant seal (*Mirounga angustirostris*) in British Columbia water and vicinity. The Canadian Field-Naturalist 59(5): 170–172.

Carl, G. C., and **I. McT. Cowan.** 1945. Notes on the salamanders of British Columbia. Copeia 1945(1): 43–44.

Carl, G. C., and **I. McT. Cowan.** 1945. Notes on some frogs and toads of British Columbia. Copeia 1945: 52–53.

Clarke, G. H., and **I. McT. Cowan.** 1945. Birds of Banff National Park, Alberta. The Canadian Field-Naturalist 59(3): 83–103.

Kendeigh, S.C., L. R. Dice, J. E. Hill, A. Leopold, H. P. Thomsen, R. W. Dexter, W. B. Davis, E. R. Hall, A. L. Nelson, C. Cottam, W. S. Bourn, T. C. Stephens, A. F. Halloran, I. McT. Cowan, F. B. McMurry, W. R. Eadie, and **L. W. Wilson.** 1945. General Notes. Journal of Mammalogy 26 (1): 86–96.

McCabe, T. T., and **I. McT. Cowan.** 1945. *Peromyscus maniculatus macrorhinus* and the problem of insularity. Transactions of the Royal Canadian Institute 25: 117–216.

Cowan, I. McT. 1946. Notes on the distribution of the chipmunks *Eutamias* in southern British Columbia and the Rocky Mountain region of southern Alberta with descriptions of two new races. Proceedings of the Biological Society of Washington 59: 107–118.

Cowan, I. McT. 1946. Antlered doe mule deer. The Canadian Field-Naturalist 60(1): 11–12.

Cowan, I. McT. 1946. Notes on the distribution of *Spizella breweri taverneri.* Condor 48(2): 93–94.

Cowan, I. McT. 1946. General report upon wildlife studies in the Rocky Mountain parks in 1946. Mimeographed report, National Parks Bureau, 19 pages.

Cowan, I. McT. 1946. Death of a Trumpeter Swan from multiple parasitism. The Auk 63(2): 248–249.

Cowan, I. McT. 1946. Parasites, diseases, injuries, and anomalies of the Columbian black-tailed deer, *Odocoileus hemionus columbianus* (Richardson), in British Columbia. Canadian Journal of Research D 24: 71–103.

Cowan, I. McT. 1946. Report of the wildlife studies in 1944 and parasites, diseases and injuries of game animals in the Rocky Mountain national parks, 1942–44. Canadian Wildlife Service Unpublished Report, Ottawa, ON. 19 pages.

Cowan, I. McT., and **J. A. Munro.** 1946. Birds and mammals of Revelstoke National Park (Part 2). Canadian Alpine Journal 29: 2: 237–256.

Cowan, I. McT., and **K. Racey.** 1946. A new pika (Genus *Ochotona*) from British Columbia. Canadian Field-Naturalist 60: 102–104.

Sibley, C. G., H. E. Broadbooks, W. H. Sholes, Jr., I. McT. Cowan, W. P. Taylor, C. Cottam, J. G. Peterson, C. W. Quaintance, R. L. Peterson, B. P. Glass, R. R. Talmadge, H. H. Dill, and **L. R. Wolfe.** 1946. From Field and Study. The Condor 48(2): 92–97.

Cowan, I. McT. 1947. Range competition between mule deer, bighorn sheep, and elk in Jasper Park, Alberta. Transactions of the 12th North American Wildlife Conference 12:5 223–227.

Cowan, I. McT. 1947. The timber wolf in the Rocky Mountain national parks of Canada. Canadian Journal of Research 25: 139–174.

Cowan, I. McT.1947. Waterfowl conditions on the Mackenzie Delta. The Murrelet 29 (2): 21–26.

Cowan, I. McT., and **J. A. Munro.** 1947. Birds and mammals of Revelstoke National Park. National Parks Bureau, Dept. of Mines and Resources, 100–121; 237–256 (Reprinted from the Canadian Alpine Journal, 29: 1 and 29: 2).

Munro, J. A., and **I. McT. Cowan.** 1947. A review of the bird fauna of British Columbia. British Columbia Provincial Museum Special Publication 2, 285 pages.

Cowan, I. McT. 1948. The occurrence of the granular tapeworm *Echinococcus granulosus* in wild game in North America. Journal of Wildlife Management 12(1): 105–106.

Cowan, I. McT. 1948. Scientific research on game and game parasites and diseases in British Columbia. Pages 16–31 *in* British Columbia Game Department, Proceedings Second Annual Game Convention, Victoria, British Columbia.

Cowan, I. McT. 1948. Waterfowl conditions on the Mackenzie Delta: 1947. Murrelet 29(2): 21–26.

Cowan, I. McT. 1949. A study of hunting in British Columbia. Proceedings Third Annual Game Convention, Victoria, British Columbia: 75–79.

Cowan, I. McT. 1949. Pheasant study in British Columbia in 1948. Pages 112–116 *in* British Columbia Game Department, Proceedings Third Annual Game Convention, Victoria, British Columbia.

Cowan, I. McT.1949. Rabies as a possible population control of Arctic *Canidae.* Journal of Mammalogy 30(4): 396-398.

Cowan, I. McT.1949. Preliminary report upon the Sayward Forest deer study, 1948-49. [Unpublished] mimeo, 5 pages.

Cowan, I.McT., and **V. C. Brink,** 1949. Natural game licks in the Rocky Mountain national parks of Canada. Journal of Mammalogy 30 (4):379–387.

Hatter, J., and **I. McT. Cowan**. 1949. Waterfowl breeding ground survey in British Columbia. British Columbia Game Commission Memorandum, Victoria, British Columbia. 2 pages.

Gabrielson, I. N., R. P. Allen, I. McT. Cowan, P. A. DuMont, R. H. Pough, and **G. A. Swanson.** 1949. Report of the A. O. U. Committee on bird protection. The Auk 67(3): 316–324.

Cowan, I. McT. 1950. Some vital statistics of big game on overstocked mountain ranges. Transactions of the North American Wildlife Conference 15: 581–588.

Cowan, I. McT. 1950. Problems of wildlife research and management in the province of British Columbia. Pages 20–27 *in* British Columbia Game Department, Proceedings Fourth Annual Game Convention, Victoria, British Columbia.

Kendeigh, S. C., H. I. Baldwin, V. H. Cahalane, C. H. D. Clarke, C. Cottam, I. McT. Cowan, P. Dansereau, J. H. Davis, F. W. Emerson, I. T. Haig, A. Hayden, C. L. Hayward, J. M. Linsdale, J. A. MacNab, and **J. E. Potzger.** 1950–51. Nature sanctuaries in the United States and Canada: A preliminary inventory. The Living Wilderness 15(35): 1–45.

Cowan, I. McT., W. S. Hoar, and **J. Hatter.** 1950. The effect of forest succession upon the quality and upon the nutritive values of woody plants used as food by moose. Canadian Journal of Research. Section D: Zoological Sciences 28 5: 249–271

Cowan, I. McT., and **R. H. Mackay.** 1950. Food habits of the marten (*Martes americana*) in the Rocky Mountain region of Canada. The Canadian Field-Naturalist 64: 100–104.

Cowan, I. McT. 1951. The diseases and parasites of big game mammals of western Canada. In Fifth Annual Game Commission Convention, Victoria, BC: 37–64.

Cowan, I. McT. 1951. Nature sanctuaries in the United States and Canada. Living Wilderness 35: 45 pages.

Cowan, I. McT. 1951. A new *Microtus* from the western Arctic of Canada. Journal of Mammalogy 32: 353–354.

Cowan, I. McT. 1951. Report on the deer population of Graham Island, Queen Charlotte Islands, British Columbia. British Columbia Game Department Unpublished Report, Victoria, British Columbia.

Cowan, I. McT. 1951. The Passenger Pigeon. Museum and Art Notes 2d series 1: 25–26.

Cowan, I. McT., and **W. B. M. Hick.** 1951. A comparative study of the mycology of the head region of three species of *Thamnophis (Reptilia, Ophidia).* Transactions of the Royal Society of Canada 35(3) (5):19–60.

Cowan, I. McT. 1952. Big game in the mountain province. Canadian Geographical Journal XLIV (6): 226–241.

Cowan, I. McT. 1952. Review: Union Bay. (The Life of a City Marsh*)* by H. W. Higman and E. J. Larrison. Journal of Wildlife Management 16 (1): 102.

Cowan, I. McT. 1952. Review: The elk of North America by O. J. Murie. The Journal of Wildlife Management 16(1): 96–97.

Cowan, I. McT. 1952. Ruts and ridges: some major issues in wildlife conservation. Proceedings of the 6th Annual BC Big Game Convention: 63–68.

Cowan, I. McT. 1952. The role of wildlife on forest land in Western Canada. Forest Chronicles 28: 42–49.

Cowan, I. McT. 1952. Waterfowl at Beacon Hill Park. Victoria Naturalist 9(2): 21–22.

Cowan, I. McT., and **C. Guiget.** 1952. Three cetacean records from British Columbia. The Murrelet 33(1): 10–11.

Cowan, I. McT., and **J. Hatter.** 1952. A trap and technique for the capture of diving waterfowl. Journal of Wildlife Management 16 (4): 438–441.

Cowan, I. McT. 1953. Getting wise to our wildlife. C-I-L Oval: 14–17.

Cowan, I. McT. 1953. Review: Birds of Washington State by S.G. Jewett et al. The Canadian Field-Naturalist 69: 29–30.

Cowan, I. McT. 1953. Riistanhoito Kanadassa. Eripainos Sumomen Riista 8: 84–109.

Cowan, I. McT. 1953. Small mammals of the western mountains. Canadian Geographical Journal XLVII (4): 130–141.

Cowan, I. McT. 1954. The distribution of the pikas (*Ochotona*) in British Columbia and Alberta. The Murrelet 35: 20–24.

Cowan, I. McT. 1954. A new northern record for Xanthus Murrelet, *Brachyrhamphus hypoleuca.* The Murrelet 35: 50.

Cowan, I. McT. 1954. An indication of population mixing in Canada geese. The Murrelet 35: 45.

Cowan, I. McT. 1954. Observations on wildlife conservation and management in Britain and Norden. British Columbia Game Department, Game Convention, Report of Proceedings 8: 22–30.

Cowan, I. McT. 1954. Review: A herd of mule deer by J. M. Linsdale and P. Q. Tomich. Journal of Wildlife Management 18(2): 274–275.

Cowan, I. McT. 1954. The occurrence of the Pleistocene wolf (*Canis dirus*) in the Rocky Mountains of Central Alberta. Canadian Field-Naturalist 68(1): 44.

Cowan, I. McT., and **M. G. Arsenault.** 1954. Reproduction and growth in the creeping vole, *Microtus oregoni serpens* Merriam. Canadian Journal of Zoology 32: 198–208.

Cowan, I. McT., and **M. F. Jackson.** 1954. Population dynamics of Barrow's Golden-eye in British Columbia—progress report. University of British Columbia, Department of Zoology Unpublished Report, Vancouver, British Columbia. 7 pages.

Robinson, D. J., and **I. McT. Cowan.** 1954. An introduced population of the gray squirrel (*Sciurus carolinensis* Gmelin) in British Columbia. Canadian Journal of Zoology 32: 61–282.

Cowan, I. McT. 1955. An instance of scabies in the marten *(Martes americana*). Journal of Wildlife Management 19(4): 499.

Cowan, I. McT. 1955. Birds of Jasper National Park, Alberta, Canada, Canadian Wildlife Service Wildlife Management Bulletin Series 2(8), 66 pages.

Cowan, I. McT. 1955. Chemical sprays and their relation to wildlife. Proceedings of the 9th Annual BC Game Convention, 10 pages.

Cowan, I. McT. 1955. Getting wise to our wildlife. Canadian Nature May–June: 90–97.

Cowan, I. McT. 1955. The challenge we take: appraisal of the 20th North American Wildlife Conference. Transactions of the 20th North American Wildlife Conference: 662–670.

Cowan, I. McT. 1955. Wildlife conservation in Canada. Journal of Wildlife Management 19: 161–176.

Cowan, I. McT. 1955. The wildlife resources in Canada. A brief to the Royal Commission on Canada's Economic Prospects. The Canadian Conservation Association, 34 pages.

Cowan, I. McT. 1955. The Whooping Crane. Bulletin of the Vancouver Natural History Society 95: 2–3.

Cowan, I. McT., and **A. J. Wood.** 1955. The normal temperature of the Columbian black-tailed deer. Journal of Wildlife Management 19: 154.

Cowan, I. McT., and **A. J. Wood.** 1955. The growth rate of the black-tailed deer *Odocoileus hemionus columbianus.* Journal of Wildlife Management 19: 331–336.

Cowan, I. McT. 1956.The gamble of game management. BC Wildlife Review 5 (1): 4–5.

Cowan, I. McT. 1956. Review: The barren ground caribou by F. Harper. Ecology 37(3): 626–627.

Cowan, I. McT. 1956. Review: Prairie Ducks by L. K. Sowls. The Canadian Field-Naturalist 70: 145.

Cowan, I. McT. 1956. What and where are the mule and black-tailed deer? Pages 335-339 *in* The deer of North America: their history and management. *Edited by* W. P. Taylor. Stackpole Co. and Wildlife Management Institute, Washington, D.C.

Cowan, I. McT. 1956. Life and times of the coast black-tailed deer. Pages 523- 617 *in* The deer of North America: their history and management. *Edited by* W. P. Taylor. Stackpole Co. and Wildlife Management Institute, Washington, D.C.

Bandy, P. J., I. McT. Cowan, W. D. Kitts, and **A. J. Wood.** 1956. A method for the assessment of the nutritional status of wild ungulates. Canadian Journal of Zoology 34: 48–52.

Kitts, W. D., I. McT. Cowan, J. Bandy, and **A. J. Wood.** 1956 The immediate post-natal growth in the Columbian black-tailed deer in relation to the composition of the milk of the doe. Journal of Wildlife Management 20 (2): 212–214.

Manzer, J. I., and **I. McT. Cowan.** 1956. Northern fur seal in the inside coastal waters of British Columbia. Journal of Mammalogy 37: 83–86.

Cowan, I. McT. 1957. The penalties of ignorance to man's biological independence. Pages 41-50 *in* Our debt to the future. *Edited by* E. G. D. Murray. Royal Society of Canada Symposium Presented on the 75th Anniversary of the Royal Society of Canada: 41–50.

Cowan, I. McT., A. J. Wood, and **W. D. Kitts.** 1957. Feed requirements of deer, beaver, bear, and mink for growth and maintenance. Transactions of the North American Wildlife Conference 22: 179–188.

Edwards, R. Y., and **I. McT. Cowan.** 1957. Fur production of the boreal forest region of British Columbia. Journal of Wildlife Management 21: 257–267.

Kitts, W. D., R. J. Bose, A. J. Wood, and **I. McT. Cowan.** 1957. Preliminaxry observations of the digestive enzyme system of the beaver (*Castor canadensis*). Canadian Journal of Zoology 35: 449–452.

Myres, M. T., I. McT. Cowan, and **M. D. F. Udvardy.** 1957. The British Columbia Nest Records Scheme. The Condor 59(5): 308–310.

Bandy, P. J., W. D. Kitts, A. J. Wood, and **I. McT. Cowan.** 1957.The effects of age and the plane of nutrition on the blood chemistry of the Columbian black-tailed deer (Odocoileus *hemionus columbiana*) B. Blood glucose, non-protein nitrogen, total plasma protein, plasma albumin, globulin and fibrinogen. Canadian Journal of Zoology 35: 283–289.

Kitts, W. D., M. C. Robertson, B. Stephenson, and **I. McT. Cowan.** 1958. The normal blood chemistry of the beaver (*Castor canadensis*), A. packed-cell volume, sedimentation rate, haemoglobin, erythrocyte diameter and blood cell counts. Canadian Journal of Zoology 36: 279–283.

Cowan, I. McT. 1959. Publications review: Survey on the Galapagos Island by I. Eibleibesfeldt. U.N.E.S.C.O. 9: 40–41.

Steenson, A. B., W. D. Kitts, A. J. Wood, and **I. McT. Cowan.** 1959. The normal blood chemistry of the beaver (*Castor canadensis*) B. blood glucose, total protein, albumin, globulin, fibrinogen, non-protein nitrogen, amino acid nitrogen, creatine, cholesterol and volatile fatty acids. Canadian Journal of Zoology 37: 9–14.

Cowan, I. McT. 1960. Sundry thoughts on fishing efficiency: how far can we go? Western Fisheries 59(4): 17–18.

Cowan, I. McT. 1960. Impressions of science in the U.S.S.R. Vancouver Institute Lecture, University of British Columbia, Vancouver, British Columbia.

Cowan, I. McT. 1960. Of mice and men – The biology of Numbers. Vancouver Institute Lecture, University of British Columbia, Vancouver, British Columbia.

Currier, A., W. D. Kitts, and **I. McT. Cowan.** 1960. Cellulose digestion in the beaver (*Castor canadensis*). Canadian Journal of Zoology 38: 1109–1116.

Cowan, I. McT. 1961. Of mice and men – Or the biology of numbers. Vancouver Institute Lecture, University of British Columbia, Vancouver, British Columbia.

Cowan, I. McT. 1961. A review of wildlife research in Canada. Resources for Tomorrow Conference 2: 889–899.

Cowan, I. McT., and **G. McT. Cowan.** 1961. The Amur Barn Swallow off British Columbia. Condor 63: 419.

Cowan, I. McT., and **V. Geist.** 1961. Aggressive behavior in deer of the genus *Odocoileus*. Journal of Mammalogy 42(4): 522–526.

Cowan, I. McT., and **V. Geist.** 1961. The North American wild sheep. Pages 58–83 *in* North American Big Game. *Edited by* R. C. Alberts. The Boone and Crockett Club. Pittsburgh, Pensylvannia.

Wood, A. J., H. C. Nordan, and **I. McT. Cowan.** 1961. The care and management of wild ungulates for experimental purposes. Journal of Wildlife Management 25(3): 295–302.

Fennell, C.W., M. Wallace, J. A. Bruce, R. A. Ryder, L. A. Roper, C. A. Ely, E. Willis, W. C. Hanna, I. McT. Cowan, and **G. McT. Cowan.** 1961. From field and study. The Condor 63(5): 417–419.

Cowan, I. McT., and **P. Johnston.** 1962. Blood serum protein variation at the species and subspecies level in deer of the genus *Odocoileus*. Systematic Zoology 11:131–138.

Cowan, I. McT., H. C. Nordan, and **A. J. Wood.** 1962. Studies in tranquilization and immobilization of deer. Canadian Journal of Comparative Medicine and Veterinary Science 26(3): 57–61.

Cowan, I. McT. 1962. Hybridization between the black-tail deer and the white-tail deer. Journal of Mammalogy 43(4): 539–541.

Cowan, I. McT. 1962. Molluscs of a single dredge haul. Pacific Northwest Shell News 2(3): 37.

Cowan, I. McT. 1962. Review: A revision of the reindeer and caribou, Genus *Rangifer* by A. W. F. Banfield, National Museum Bulletin. The Canadian Field-Naturalist 76: 168–169.

Krebs, C. J., and **I. McT. Cowan.** 1962. Growth studies in reindeer fawns. Canadian Journal of Zoology 40(5): 863–869.

Nordan, H.C., A. J. Wood, and **I. McT. Cowan**. 1962. Further studies on immobilization of deer with succinylcholine. Canadian Journal of Comparative Medicine and Veterinary Science 26(10): 246–248.

Wood, A. J., I. McT. Cowan, and **H. Nordan.** 1962. Periodicity of growth in ungulates as shown by deer of the genus *Odocoileus*. Canadian Journal of Zoology 40: 593–603.

Cowan, I. McT. 1963. Report of the standing committee of conservation [as Chair]. Proceedings of the 10th Pacific Science Congress: 209–256.

Cowan, I. McT. 1963. *Tonicella insignis* Reeve in British Columbia. Pacific Northwest Shell News 3(5): 53.

Cowan, I. McT. 1963. The preservation of colour in chitons. Pacific North West Shell News 3(6): 65.

Lewall, E., and **I. McT. Cowan.** 1963. Age determination in black-tailed deer by degree of ossification of the epiphyseal plate in the long bones. Canadian Journal of Zoology 41: 529–636.

Low, W. A., and **I. McT. Cowan.** 1963. Age determination of deer by annular structure of dental cementum. Journal of Wildlife Management 27 (3): 466–471.

Stewart, S. F., H. A. Nordan, A. J. Wood, and **I. McT. Cowan.** 1963. Changes in the plasma lipids of the black-tailed deer throughout a year. XVI International Congress of Zoology 2: 46.

Cowan, I. McT. 1964. A naturalist-scientist's attitude toward national parks. Canadian Audubon May–June: 93–96.

Cowan, I. McT. 1964. The egg capsule and young of *Beringius eyerdami* Smith (Neptuneidae). Mollusca Gastropoda). The Veliger 7(1): 43-45.

Cowan, I. McT. 1964. A new species of the Lamellibranch genus *Aligena* from Western Canada. The Veliger 7(2): 108-109.

Cowan, I. McT. 1964. New information on the distribution of marine mollusca on the coast of British Columbia. The Veliger 7(2): 110–113.

Cowan, I. McT. 1964. The egg capsule and young of the gastropod *Pyrulofusus harpa* (Morch). Veliger 8(1): 1-2.

Cowan, I. McT. 1964. Report on term research grant: t 152/I. McT. Cowan – study of mammalian adaptation to physical and biotic factors. University of British Columbia, Department of Zoology, Vancouver, British Columbia. 25 pages.

Cowan, I. McT. 1964. Review: Proceedings of the first national white-tailed deer disease symposium by M. F. Baker. Journal of Wildlife Management 28(1): 186–188.

Cowan, I. McT. 1964. Wildlife. Proceedings of the 15th British Columbia Resources Conference: 87–89.

Cowan, I. McT. 1964. The holotype of the Franklin Grouse (*Canachites franklinii*). Canadian Field-Naturalist 78(2): 127–128.

Cowan, I. McT. 1964. Threatened species of mammals in North America. XVI International Congress of Zoology 8: 17–21.

Cowan, I. McT., and **J. H. McLean.** 1964. A new species of *Puncturella (cranopsis)* from the Northeastern Pacific. The Veliger 11(2): 105-108.

Grant, P. R., and **I. McT. Cowan.** 1964. A review of the avifauna of the Tres Marias Islands, Nayarit, Mexico. The Condor, 66(3): 221–228.

Cowan, I. McT. 1965. A new necessity of the new age – the PhD. UBC Alumni Chronicle Spring: 7–8.

Cowan, I. McT. 1965. Conservation and man's environment. Nature 208 (5016): 1145–1151.

Cowan, I. McT. 1965. Review: Geographical and Sexual Variation in the Long-tailed Jaeger, (*Stercorarius longicaudus Vieillot*) by T. H. Manning. The Murrelet 46(1): 17.

Cowan, I. McT., and **C. J. Guiguet.** 1965. The mammals of British Columbia. British Columbia Provincial Museum Handbook 11: 413 pages.

Wood, A. J., I. McT. Cowan, and **M. J. Daniel.** 1965. Organ weight-body weight relations in the family Mustelidae: the mink (*Mustela vision*). Canadian Journal of Zoology 43(1): 55–68.

Cowan, I. McT. 1966. Conservation and man's environment. Pages 61-80 *in* Knowledge Among Men. Eleven essays on science, culture and society commemorating the 200th anniversary of the birth of James Smithson. Simon and Schuster and the Smithsonian Institute.

Cowan, I. McT. 1966. Management, response, and variety. Pages 55-65 *in* Future Environments of North America Series. *Edited by* F. F. Darling and J. P. Milton. Garden City, New York: Natural History Press.

Smith, A. G., and **I. McT. Cowan.** 1966. A new deep-water chiton from the Northeastern Pacific. Occasional Papers of the California Academy of Sciences 56: 1–15.

van Tets, P., and **I. McT. Cowan.** 1966. Some sources of variation in blood sera of deer (*Odocoileus*) as revealed by starch-gel electrophoresis. Canadian Journal of Zoology 44(4): 631–647.

Cowan, I. McT. 1967. Man and his environment. Vancouver Institute Lecture, University of British Columbia, Vancouver, British Columbia.

Cowan, I. McT. 1967. Water and wildlife. Proceedings of the 17th British Columbia Resources Conference: 76–81.

van Tets, P., and **I. McT. Cowan.** 1967. The starch-gel electrophoretic serum lipid fraction of two species of deer in the genus *Odocoileus*. Canadian Journal of Zoology 45(4): 579–581.

Cowan, I. McT., H. P. Oberlander, P. Larkin, and **C.S. Holling.** 1968. Man and his environment and doomsday. Vancouver Institute Lecture, University of British Columbia, Vancouver, British Columbia.

Cowan, I. McT. 1968. The role of ecology in the National Parks. Pages 931-939 *in* The Canadian national parks: today and tomorrow. *Edited by* J. G. Nelson and R. C. Scace. Studies in Landscape History and Landscape Change. Number 3. National and Provincial Parks Association of Canada and the University Calgary.

Cowan, I. McT. 1968. Wilderness-concept, function and management. The Horace M. Albright Conservation Lectureship, University of California, School of Forestry and Conservation, Berkley, 36 pages. Also in Conservators of hope: the Horace M. Albright lectures, University of Idaho Press, 1988.

Cowan, I. McT. 1968. The interrelationships of certain boreal and Arctic species of *Yoldia* Moller. The Veliger 11(1): 51-58.

Lykke, J., and **I. McT. Cowan.** 1968. Moose management and population dynamics on the Scandinavian Peninsula, with special reference to Norway. Proceedings of the North American Moose Workshop 5: 1–22.

Nordan, H. C., I. McT. Cowan, and **A. J. Wood.** 1968. Nutritional requirements and growth of black-tailed deer, *Odocoileus hemionus columbianus*, in captivity. Comparative Nutrition of Wild Animals. Proceedings of a symposium, London, 1966. Academic Press, New York. 430 pages.

Wood, A. J., and **I. McT. Cowan.** 1968 Post natal growth. In A Practical Guide to the Study of the Productivity of Large Herbivores. *Edited by* Frank B. Goley and Helmut K. Buechner, IBP Handbook Number 7, Blackwell Scientific Publications: 106–113.

Cowan, I. McT. 1969. Ecology and northern development. Arctic 22(1): 3–12.

Cowan, I. McT. 1969. Ecology of north—knowledge is key to sane development. Science Forum 2: 3.

Cowan, I. McT. 1969. Wild values for the future: wild land and the Sportsmen's Federation. The 13th Annual Convention of the British Columbia Wildlife Federation, New Westminster, British Columbia.

Cowan, I. McT. 1969. A new species of gastropod (Fissurellidae, *fissurisepta*) from the Eastern North Pacific Ocean. The Veliger 12(1): 24-26.

Cowan, I. McT., and **P. J. Bandy.** 1969. Observations on the hematology of several races of black-tailed deer (*Odocoileus hemionus*). Canadian Journal of Zoology 47(5): 1021–1024.

Cowan, I. McT., and **L. Karstad.** 1969. Post-mortem examinations. Pages 251–258 *in* Wildlife Management Techniques (Third edition, revised). *Edited by* Robert H. Giles. The Wildlife Society, Washington, DC.

Aleksiuk, M., and **I. McT. Cowan.** 1969. Aspects of seasonal energy expenditure in the beaver (*Castor canadensis* Kuhl) at the northern limit of its distribution. Canadian Journal of Zoology 47: 471–481.

Aleksiuk, M., and **I. McT. Cowan.** 1969. The winter metabolic depression in arctic beavers (*Castor canadensis* Kuhl) with comparisons to California beavers. Canadian Journal of Zoology 47: 965–979.

Leopold, S., with **C. C. Cottam, I. McT. Cowan, I. N. Gabrielson,** and **T. L. Kimball.** 1969. The National Wildlife Refuge System. Tranactions of the 33rd North American. Wildlife Natural Resources Conference, Washington, D.C.: Wildlife Management Institute: 30–54.

Mosby, H., I. McT.Cowan, and **L. Karstad.** 1969. Collection and field preservation of biological materials. Pages 259–276 *in* Wildlife Management Techniques (Third edition, revised). *Edited by* Robert H. Giles. The Wildlife Society, Washington, D.C.

Taber, R. D., and **I. McT. Cowan.** 1969. Capturing and marking wild animals. Pages 277–318 *in* Wildlife Management Techniques (Third edition, revised). *Edited by* Robert H. Giles. The Wildlife Society, Washington, D.C.

Cowan, I. McT. 1970. Foreword *in* The Wolf, Ecology and Behavior of an Endangered Species *by* L. D. Mech, USFWS, Natural History Press, Garden City, New York, 384 pages.

Cowan, I. McT., and **W. McCrory.** 1970. Variation in the mountain goat, *Oreamnos americanus* (Blainville). Journal of Mammalogy 51: 60–73.

Ommundsen, P., and **I. McT. Cowan.** 1970. Development of the Columbian black-tailed deer (*Odocoileus hemionus columbianus*) during the fetal period. Canadian Journal of Zoology 48(1): 123–132.

Bandy, P. J., I. McT.Cowan, and **A. J. Wood.** 1970. Comparative growth in four races of black-tailed deer (*Odocoileus hemionus*). Part I. Growth in body weight. Canadian Journal of Zoology 48: 1401–1410.

Nordan, H. C., I. McT. Cowan, and **A. J. Wood.** 1970. The feed intake and heat production of the young black-tailed deer (*Odocoileus hemionus columbianus*). Canadian Journal of Zoology 48(2): 275–282.

Cowan, I. McT. 1971. Summary of the symposium on the status of native cats of North America. Pages 2–8 *in* Proceedings of symposium on the native cats of North America their status and management. *Edited by* S. Jorgensen and D. L. Mech. United States Department of the Interior, Portland, Oregon.

Hebert, D. M., and **I. McT. Cowan.** 1971. Natural salt licks as a part of the ecology of the mountain goat. Canadian Journal of Zoology 49:5–610.

Jonkel, C. J., and **I. McT. Cowan.** 1971. The black bear in the spruce-fir forest. Wildlife Monograph 27. 57 pages.

Hebert, D. M., and **I. McT. Cowan.** 1971. White muscle disease in the mountain goat. Journal of Wildlife Management 35(4): 752–756.

Calaby, J. H., H. Henry, and **I. McT. Cowan.** 1971. The Mountain Pygmy Possum *Burramys parvus* Broom (Marsupalia) in the Kosciusko National Park, New South Wales. Commonwealth Scientific and Industrial Research Organization, Division of Wildlife Research Technical Paper Number 23, Melbourne, Australia. 11 pages.

Cowan, I. McT. 1972. The status and conservation of bears (*Ursidae*) of the world — 1970. International Conference on Bear Research and Management 2: 343–367.

Cowan, I. McT., and **A. G. Raddi.** 1972. Pelage and molt in the black-tailed deer (*Odocoileus hemionus* (Rafinesque)). Canadian Journal of Zoology 50(5): 639–647.

R. Cathro, G. Collins, I. McT. Cowan, and **M. Stutter.** 1971. Submission to: The Honourable Jean Chrétien, Minister of Indian Affairs and Northern Development, Ottawa, 6 UBC Law Review 101.

Cowan, I. McT., and **W. C. Holloway.** 1973. Threatened deer of the world: conservation status. Biological Conservation 5 (4): 243–250.

Cowan, I. McT. 1973. The conservation of Australian waterfowl. Australian Government Publishing Service, Canberra, 83 pages.

Cowan, I. McT. 1973. Review: The Great Barrier Reef by I. Bennett. Pacific Affairs 46(1): 180.

Sirenko, B. I. 1973. Amphipacific distribution of chitons (Loricata) and their new species in the North-West Section of the Pacific Ocean. Zoological Journal, Volume 52(5): 669-667, Moscow, USSR. *Translated for, and edited* by **I. McT. Cowan** and **Allyn G. Smith**, published in Of Sea and Shore, Summer 1974, Port Gamble Washington.

Cowan, I. McT. 1974. Keynote address. 1974 Annual Wildlife Diseases Conference, the Wildlife Disease Association, Pacific Grove, California.

Cowan, I. McT. 1974. Management implications of behaviour in the large herbaceous mammals. Pages 921–934 *in* The behaviour of ungulates and its relation to management. Volume 2. *Edited by* V. Geist and F. Walther. International Union for Conservation of Nature. New Series Publication 24. Morges, Switzerland.

Cowan, I. McT. 1974: *Sabia conica* (Schumacher) on the Pacific Coast of North America. The Veliger 16(3): 290.

Cowan, I. McT. 1974. The west American Hipponicidae and the application of *Malluvium, Antisabia,* and *Hipponix* as generic names. The Veliger 16(4): 377-382.

Cowan, I. McT., and **W. C. Holloway.** 1974. Threatened deer of the world: research programs for conservation. Biological Conservation 6 (2): 111–117.

Cowan, I. McT., A. M. Oriordan, and **J. S. McT. Cowan.** 1974. Energy requirements of the dasyurid marsupial mouse *Antechinus swainsonii* (Waterhouse). Canadian Journal of Zoology 52: 269–275.

Cowan, I. McT., G. C. Andrew, T. C. Byrne, J. F. Ellis, L. S. Gansner, R. Hughes, J. Patterson, and **E. E. Wallach.** 1974. Royal Commission on postsecondary education in the Kootenay Region. Queens Printer 2 Volumes.

Johnson, S. R., and **I. McT. Cowan.** 1974. Thermal adaptation as a factor affecting colonizing success of introduced *Sturnidae* (Aves) in North America. Canadian Journal of Zoology 52 (12): 1559–1576.

Cowan, I. McT. 1975. Transcript of Mackenzie Valley Pipeline Inquiry, Yellowknife. Awest Reporting Ltd., Burnaby, British Columbia 47: 6267.

Johnson, S. R., and **I. McT. Cowan.** 1975. The energy cycle and thermal tolerance of the starlings (Aves, Sturnidae) in North America. Canadian Journal of Zoology 53: 55–68.

Thomas, D. C., and **I. McT. Cowan.** 1975. The pattern of reproduction in female Columbian black-tailed deer, *Odocoileus hemionus columbianus*. Journal of Reproduction and Fertility 44: 261–272.

Hoefs, M., I. McT. Cowan, and **V. J. Krajina.** 1975. Phytosociological analysis and synthesis of Sheep Mountain: southwest Yukon Territory, Canada. Syesis 8: 125–228.

Cowan, I. McT. 1976. Foreword in Spatsizi by T. A. (Tommy) Walker. Nunaga Publishing 272 pages.

Haber, G. C., C. J. Walters, and **I. McT. Cowan.** 1976. Stability properties of wolf-ungulate system in Alaska and management implications. UBC Institute of Animal Resource Ecology, Report R-5-R, 104 pages.

Cowan, I. McT. 1977. Cumulative impact of development of the Mackenzie Estuary/Delta, NWT. Pages 71–82 *in* Mackenzie Delta: Priorities and Alternatives. Conference Proceedings, 3–4 December 1975. CARC Ottawa, 193 pages.

Cowan, I. McT. 1977. Natural resources research in Canada's National Parks: An evaluation. Parks Canada, Ottawa, 135 pages.

Cowan, G. McT., and **I. McT. Cowan.** 1977. New chiton of the genus *Mopalia* from the northeast Pacific coast. Syesis 10: 45–52.

Elliott, J. P., I. McT. Cowan, and **C. S. Holling.** 1977. Prey capture by the African lion. Canadian Journal of Zoology 55: 1811–1828.

Cowan, I. McT., and **W. C. Holloway.** 1978. Geographical location and current conservation status of the threatened deer of the world, Deer Specialist Group of the Survival Service Commission of IUCN. An introductory paper in Threatened Deer. IUCN, Alden Press: 11–20.

Cowan, I. McT., and **W. C. Holloway.** 1978. Research towards conservation of threatened deer of the world. Pages 329–337 *in* Threatened deer. International Union for Conservation of Nature and Natural Resources, London, England.

Elliott, J. P., and **I. McT. Cowan.** 1978. Territoriality, density and prey of lion in Ngorongoro Crater, Tanzania. Canadian Journal of Zoology 56: 1726–1734.

Hoefs, M., and **I. McT. Cowan.** 1979. Ecological investigation of a population of Dall sheep (*Ovis dalli dalli* Nelson). Syesis 12 (Supplement 1). 81 pages.

Cowan, I. McT. 1979. Part imperforate stamps in British Columbia. The Canadian Philatelist 30(2): 89–96.

Cowan, I. McT. 1979. New information on the Yukon territorial law stamps. BNA Topics. 36(2): 43–45.

Cowan, I. McT. 1979. The Dawson Mining Court Law stamps of Yukon Territory. BNA Topics 36(3): 50–52.

Bowen, W. D., and **I. McT. Cowan,** 1980. Scent marking in coyotes. Canadian Journal of Zoology 58: 473–480.

Cowan, I. McT. 1980. The basis of endangerment. Pages 3–20 *in* Proceedings of Threatened and endangered species and habitats in British Columbia and Yukon. R. Stace-Smith, L. Johns, and P. Joslin. BC Fish and Wildlife Branch, Ministry of Environment. 320 pages.

Cowan, I. McT. 1980. The impact of land use policy in western Canada upon wildlife, 1945 to 1980. Pages 133-170 *in* Alberta Society of Professional Biologiests, April 22-23, 1980. Symposium on environmental management strategies: past, present and future. Edmonton, Alberta. The Alberta Society of Professional Biologists and Alberta Environment, Edmonton, Alberta. 293 pages.

Cowan, I. McT. 1981. Wildlife conservation issues in northern Canada. Canadian Environmental Advisory Council. Report 11, 30 pages.

Cowan, I. McT. 1982. Faunal diversity as a habitat goal. Pages 20-130 *in* British Columbia land for wildlife past, present and future. *Edited by* D. Day and R. Stace-Smith. Proceedings of Land for Wildlife Symposium, Simon Fraser University, BC Ministry of Environment.

Cowan, I. McT. 1984. Some environmental considerations in the planning, construction, and maintenance of northern roads, with relevance to the MacKenzie Valley Highway. *In* J. Keith Fraser & Canadian Environmental Advisory Council. Selected papers from assemblies of the environment councils of Canada, 1975–1980 Canadian Environmental Advisory Council, Ottawa.

Cowan, I. McT. 1985. Forestry and forest wildlife, a conference overview. The Forestry Chronicle 61(2): 200–202.

French, R. D., E. Richardson, D. van Oudeno, L. J. LaFrance, T. W. Turner, H. A. Clampett, J. Lehr, J. Schonfeld, C. Emery, W. Rockett, M. O. Bakker, and **I. McT.Cowan.** *Editors.* 1954–1985. Revenue group news, revenue stamps. BNA Topics 11(5) to 42(5).

Cowan, I. McT. 1987. Science and the conservation of wildlife in British Columbia. In Our Wildlife Heritage —100 years of wildlife management, *Edited by* A. Murray. Centennial Wildlife Society of British Columbia: 85–106.

Cowan, I. McT. 1987. The marine mammals of British Columbia, their status and distribution. Pages 95-104 *in* The wildlife of northern British Columbia – past, present and future: the proceedings of a symposium, November 1987. Spatsizi Association for Biological Research, Smithers British Columbia.

Lindblad, S. O., and **L. Lindblad.** *Editors.* With contributions from **G. Lindsay, I. McT. Cowan,** and **D. Cornejo.** 1987. Baja California. Rizzoli, 184 pages.

Cowan, I. McT., and **T. Beck.** 1988. Volume 4 *in* Canadian Encyclopedia. *Editor in chief* James H. Marsh. Hurtig Publishers, Edmonton, Alberta.

Cowan, I. McT. 1989. Birds and mammals on the Queen Charlotte Islands. Pages 175-186 *in* The Outer Shores. *Edited by* G. G. E. Scudder and N. Gessler. Queen Charlotte Islands Museum, Skidegate.

Cowan, I. McT. 1989. Room at the top? Pages 249-266 *in* Endangered Spaces: the future for Canada's wilderness. *Edited by* M. Hummel Key Porter Books, Ltd, Toronto.

Cowan, I. McT. 1990. The day before the show. Vancouver Island Rock and Alpine Garden Society newsletter, (March 1990): 1–3.

Campbell, R. W., N. K. Dawe, I. McT. Cowan, J. M. Cooper, G. K. Kaiser, and **M. C. E. McNall.** 1990. The birds of British Columbia, Volume I. Introduction and Loons through Waterfowl. Royal British Columbia Museum; Environment Canada, Canadian Wildlife Service, Victoria, British Columbia; [Ottawa, Ontario] 514 pages.

Campbell, R. W., N. K. Dawe, I. McT. Cowan, J. M. Cooper, G. K. Kaiser, and **M. C. E. McNall.** 1990. The birds of British Columbia, Volume II. Diurnal Birds of Prey through Woodpeckers. Royal British Columbia Museum; Environment Canada, Canadian Wildlife Service, Victoria, British Columbia [Ottawa, Ontario], 636 pages.

Hummel, M., and **I. McT. Cowan.** 1990. Conservation strategy for large carnivores in Canada. World Wildlife Fund Canada, Toronto, Ontario. 98 pages.

Cowan, I. McT. 1991. Foreword. Pages *v–vi in* Wild hunters — predators in peril *by* Monte Hummel and Sherry Pettigrew. Key Porter Books, Toronto, Ontario. 244 pages

Cowan, I. McT. 1992. Capture and maintenance of cetaceans in Canada. A report prepared by the Advisory Committee on Marine Mammals. Report to the Minister, Fisheries and Oceans, Ottawa. 30 November.

Geist, V., and **I. McT. Cowan.**1995. Wildlife conservation policy, Detselig Enterprises, 308 pages.

Cowan, I. McT. 1996. Conservation and man's environment. Parks and Recreation 3(2).

Campbell, R. W., N. K. Dawe, I. McT. Cowan, J. M. Cooper, G. K. Kaiser, M. C. E. McNall, and **G. E. John Smith.** 1997. The birds of British Columbia, Volume III. Passerines, Flycatchers through Vireos. University of British Columbia Press, 693 pages.

Cowan, I. McT. 1998. Moments from the education of an ornithologist. The Doris Huestus Spiers Lecture, Picoides 11(2): 17–22.

Kennedy, E., and **I. McT. Cowan.** 1998. Sixteen years with a Bald Eagle's, *Haliaeetus leucocephalus*, nest. Canadian Field-Naturalist 112(4): 704–706.

Campbell, R. W., N. K. Dawe, I. McT.Cowan, J. M. Cooper, G. W. Kaiser, A. C. Stewart, and **M. C. E. McNall.** 2001. The birds of British Columbia: Volume IV: passerines (wood-warblers through Old World sparrows). University of British Columbia Press, Vancouver British Columbia. 739 pages.

Cowan, I. McT., N. K. Dawe, R. W. Campbell and **A. C. Stewart.** 2001. Avian biodiversity, ecological distribution, and patterns of change. Pages 633–678 *in* The birds of British Columbia: Volume 4: passerines (wood-warblers through Old World sparrows) *by* R. W. Campbell, N. K. Dawe, I. McT. Cowan, J. M. Cooper, G. W. Kaiser, A. C. Stewart, and M. C. E. McNall. University of British Columbia Press, 739 pp.

Dawe, N. K., I. McT. Cowan, R. W. Campbell, and **A. C. Stewart.** 2001. What lies in store for the birds of British Columbia? New philosophies, concerns, and conservation challenges. Pages 679–695 *in* The birds of British Columbia: Volume 4: passerines (wood-warblers through Old World sparrows) *by* R. W. Campbell, N. K. Dawe, I. McT. Cowan, J. M. Cooper, G.W. Kaiser, A.C. Stewart and M. C. E. McNall. University of British Columbia Press. 739 pages.

Cowan, I. McT. 2001. Biology of the desert. Presentation to the Victoria Rhododendron Society.

Cowan, I. McT. 2004.The law stamps of Yukon, 1902–1971. The British North America Philatelic Society (BNAPS) Exhibit Series 33:104 pages.

Cowan, I. McT. 2005. The law stamps of British Columbia and their uses 1879–1984. The British North America Philatelic Society (BNAPS) Exhibit Series 36: 170 pages.

Cowan, I. McT. 2005. Foreword. Page IV in James Sirois. 2005. Grizzly chronicles of the Dean & Kimsquit rivers, British Columbia. Skookum Press, Hagensbourg, BC. 272 pages.

Cowan, I. McT. 2006. Foreword *in* The Nature Trust of British Columbia — Over 35 Years of Conservation, 96 pages.

Cowan, I. McT. 2010. Badger, Marten, Mink, Otter, Sea Otter, Seal, and Skunk. *In* The Canadian Encyclopaedia. [online] http://www.thecanadianencyclopedia.com.

Accepted 15 December 2010

The Whale Man of Newfoundland and Labrador: Jon Lien 1939-2010

WAYNE LEDWELL, KRISTINA CURREN, JULIE HUNTINGTON, and CATHERINE HOOD

Ledwell, Wayne, Kristina Curren, Julie Huntington, and Catherine Hood, 2010. The Whale Man of Newfoundland and Labrador: Jon Lien 1939-2010. Canadian Field-Naturalist 124(4): 384–398.

Born: 19 March 1939, in Clark, South Dakota, U.S.A.
Died: 14 April 2010, in St. John's, Newfoundland, Canada.

> "He is at home behind a podium, in a fishing boat, in the belly of a whale, or in a fisherman's kitchen." *Citation for Dr. Jon Lien's Order of Newfoundland and Labrador*

Dr. Jon Lien was truly an extraordinary man—he was both a force of nature and larger than life. He was warm-hearted, welcoming, humorous, everlastingly inquisitive, passionate, tireless, indomitable, and incredibly knowledgeable. He loved the land, the sea, the whales, his students, his farm, and his friends and family. Jon knew, better than anyone, how to experience joy and wonder in every moment and how to live life to its fullest. His "joie de vie," his curiosity about everything from the mundane to the arcane, his devotion to cause, and his laughter were infectious. No one who met Jon could remain untouched by or forget him.

The Early Years

Ordin Jon Lien was the eldest of four children born to Ordin Justus and Alvera Seim. Born in Clark, South Dakota, on 19 March, 1939, Jon grew up during the scarcity and rationing of World War II. He enjoyed a good family life and learned the values of cooperation, community involvement, and respect for elders.

Jon's love for and interest in animals came at an early age. When his youngest sister, Karin, was born, he was asked if he liked the new baby. His reply? "I'd rather a chicken!"

At the age of four years, Jon rescued a baby squirrel whose mother had been run over by a car. He fed it with a doll's baby bottle. When the squirrel grew up and became aggressive, he decided it was time to release it back outdoors. Before doing so, however, he gave the squirrel's tail a crew cut so he could recognize it if it stayed around.

Jon and his good friend, Larry Larrabee, built a canvas-covered canoe from a design in Popular Mechanics, raced push carts constructed from baby carriage wheels, broom handles, and clothes-line rope, competed in soapbox derbies and played a lot of sandlot baseball. In summer they fished for bullheads on their homemade raft in Willow Creek. The fish were always cleaned and donated to the local retirement home.

When he was older, Jon's summers were spent on his uncles' farms working with pigs, cattle, and chickens. One summer day, he came home and announced to his parents that he wanted to raise chickens. With little consultation, 500 baby chicks were delivered to their door and Jon turned the garage into a chicken house. When it came time to sell the chickens in his father's store, the whole family helped with chopping, dipping, and plucking. For a short while, Jon's fresh, home-grown chicken became a popular Sunday dinner meal in his Watertown neighbourhood and garnered a substantial savings for his first year of college.

Friends have said that Jon's youth and teens were dominated by three themes: animals, hard work, and deep thoughts. He carried these themes throughout his life. Jon was mentored by pastors Hinderlie and Bagne in his Lutheran Church in Watertown, South Dakota. He began to read theology (writings of Martin Luther), philosophy, and ecology. Jon was nurtured by his study in the ideals of fairness and equality. He developed a sincere love of nature, and learned to express himself in discussion, debate and writing.

In 1957, Jon chose to attend St. Olaf College, a liberal arts school in Northfield, Minnesota, to study arts and literature. In his second year, his parents moved to Northfield and purchased the Ole Store, a grocery store and café, so that Jon's siblings could also attend St. Olaf College. That year, Jon also met Judy Traastad. They fell in love and married after graduation in 1962.

Jon spent his summers during college working for the Plymouth Canoe Base in the Quetico Wilderness of northern Minnesota. He also took leave in his third year at St. Olaf for a winter assignment at the base. There he worked with troubled youth from the Minneapolis area and decided that psychology would be valuable as an advanced degree.

Jon was accepted for graduate study at Washington State University in Pullman, Washington. In the fall of 1962 he and Judy travelled west to Washington. Judy would teach elementary school and Jon would embark on an advanced degree in clinical psychology. After a great deal of clinical coursework and internship, Jon was attracted to the animal behaviour studies and the depth of Veterinary Science offered at WSU. It became very clear to him that animal behaviour should be his life's work. His chief mentor Dr. Dud Klopfer, a bril-

liant and complex thinker, brought out the best in Jon. They designed creative research and Jon's disciplined commitment and work ethic brought interesting and valuable results. He was outstanding in his class.

In 1966 Jon and Judy chose their first family pet. A Newfoundland puppy. A serendipitous choice signalling unbeknownst to them, a new course for the couple.

A New Country

Upon earning his doctorate — his thesis was on the behaviour of the Leach's Storm Petrel — Jon had competing job offers from Hong Kong, Chile, Alberta, and Montreal. After a conference trip to New York City's American Museum of Natural History and the lab of T. C. Schneirla, he was encouraged to apply for a position at Memorial University in Newfoundland. One trip to Newfoundland was enough to make him fall in love with the island, and he accepted a position at Memorial University in 1968. Soon after, as he would often say, the community of Portugal Cove chose him and Judy. A fisherman and neighbour, Joe Miller, found them a six-acre parcel of land that came with a deed from Queen Victoria, and it was there that they established their house and organic farm. The house was hand-built with the help of friends over three weekends, with most of the lumber coming from the old Bowring Salt warehouse on the south side of St. John's. When the Bell Island mine closed, Jon bought the used hardwood flooring from its office and laid it throughout the house. He and Judy dug and rocked the well, put panes in the French window frames throughout the house, plastered the walls and built the fireplaces. Jon attacked each home "making" challenge with joy and enthusiasm!

Jon loved teaching and set up an old barn on Mount Scio Road for offices and research space. He used St. John's Harbour, city ponds, and Conception Bay for his initial work with seabirds. Later, the outlying bays and coastal communities became his laboratories. In each outport and on every project, Jon made friends and good relationships. In 1977 after three years of hearing "strange nocturnal noises" Lien and his students confirmed the only known breeding colony of manx shearwaters *Puffinus puffinus* in North America on Middle Lawn Island in Placentia Bay.

Whale Research Group

During the late 1970s, a new problem emerged in Newfoundland and Labrador waters. In their search for food, humpback whales were colliding with and becoming entangled in the fishing gear of inshore fisherman. In 1978, Jon received a call from fishermen about a humpback whale that had been entangled in a net for several months and was gradually starving. Jon arrived on the scene and managed to release the animal. It wasn't long before other fishermen in the same predicament were calling him.

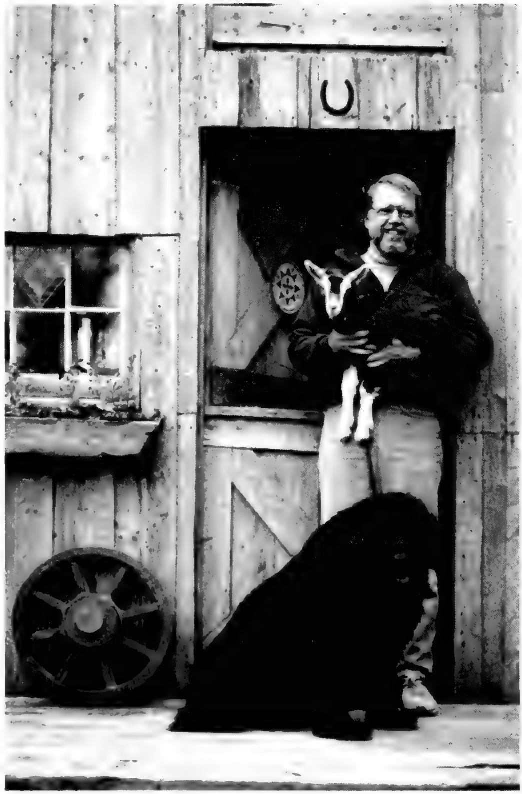


FIGURE 1. Jon Lien at home in Newfoundland outside his barn with his Newfoundland dog Jenny and a goat kid.

It was the beginning of his destiny: Jon secured a small government research grant and founded the Whale Research Group, the principle focus of which was the Entrapment Assistance Program. Whales tangled in fishing nets were a significant problem for both the animals and men. Previously, the entrapped whale often died, and the fishermen who owned the ruined nets suffered serious financial losses and lost their chance at earning an income for their family for a part or all of the short fishing season. The Entrapment Assistance Program offered technical assistance and services to fishermen and entrapped animals across the province. Fishermen responded and found at last that they had a committed partner to assist them with this problem. At its peak, the program dealt with 150 entrapped humpbacks each year and 11 different species of whales and dolphins were safely released from fishing gear. The Whale Research Group also ran an educational program for schools.

As the leader of the Whale Research Group, Jon became passionately committed to marine environment conservation as well as the welfare of fishermen. He had a trusted relationship with a fishing community that generally regarded scientists with suspicion, and

he was at the forefront of a new generation of fisheries researchers who learned to work with fishermen rather than work around them. Jon is credited with saving hundreds of whales trapped in fishing gear, but he always considered the "endangered fisherman" as well, helping them to haul in and mend their nets after an entanglement and encouraging them to tell their story.

Jon was one of the first researchers to use an ecosystem approach to whale conservation. His understanding that whales, fish stocks, seabirds, and fishermen were all inexorably linked both ecologically and economically was radically different from the single-species management blueprint of the day. He invented a series of alarm systems including the "Lien pinger" to warn whales away from fishing nets and prevent entrapments, and he pioneered entanglement rescue techniques that are now used all over the world. His work earned him unequalled respect from both fishermen and scientists around the globe.

Education was always a main focus for Jon, and graduate students from across Canada and the United States, England, Brazil, Argentina, and Germany applied to work with and be mentored by the "Whale Man." He was unfailingly generous with his students, offering them beds in his cabin if they had no place to stay, finding scholarship money for them, and helping them to publish their work in scientific journals. His encouragement of academic excellence and practical knowledge gained through hands-on experience transformed his graduate students into independent and motivated researchers.

FIGURE 2. Jon Lien attaches whale alarma to a cod net.

Environmental Conservation

Jon's professional life expanded in the late 1980s: he helped establish new policies through the International Whaling Commission; he shared his ideas and counsel through speaking engagements throughout the world; he cooperated in various studies in Australia, Holland, China, Brazil, Trinidad, Indonesia, and the United States; and after visiting marine aquariums around the world, he completed a major report titled "Cetaceans in Captivity" for the Canadian government. He believed that ordinary people should have contact with whales and the sea, and he worked with tour boat operators to create a Code of Conduct for Whale Watching in Newfoundland's coastal waters.

Jon was passionate about environmental conservation. He helped to create, guide, and work on behalf of the National Parks and Marine Protected Areas, the Canadian Parks and Wilderness Society's Newfoundland and Labrador Chapter, the Protected Areas Association of Newfoundland and Labrador, and the Torngat Mountains National Park.

Jon was also an active member of many provincial, national, and international organizations and committees. These included the Department of Fisheries and Oceans' Minister's Advisory Committee on Oceans, the Terra Nova Development Project Environmental Assessment Panel, the International Union for Conservation of Nature Commission on National Parks and Protected Areas, the Fisheries National Roundtable on the Environment and the Economy, and the Fisheries Resource Conservation Council. He also spent time at the United Nations working on Law of the Sea policy.

For his work, Jon was awarded the Order of Canada, the Order of Newfoundland and Labrador, the 125th Anniversary of the Confederation of Canada Commemorative Medal, the Lifetime Achievement Award from the Newfoundland and Labrador Department of Environment and Conservation, the Keyes Award for Research and Conservation, the Department of Fisheries and Oceans' Deputy Minister's Award, the World Environment Day Award, and an Honorary Doctor of Science from St. Olaf College.

"Jon Stories"

Jon left a zodiac full of stories wherever he worked and those stories took shape immediately when people got together who had worked with him. Like a cat, Jon seemed to have nine lives. One brush with death took place in Australia while assisting scientists with whale and shark deterrents. He was helping a friend

bait shark hooks along a stretch of shoreline known for shark attacks and where a swimmer had been taken just days before. When the automatic trawl line full of hooks advanced, Jon's hand was hooked and he was pulled off the boat. The skipper of the boat jumped in after him and the boat sped off with a mind of its own. "I'll make it!" Jon assured the skipper. He cut the trawl line with his Swiss army knife to free himself, got rid of his shoes, and swam a full mile back to shore, bleeding, dragging a buoy, and with the shark hook still embedded in his palm. The jaws of life were needed to cut through and remove the hook from his hand, and Jon escaped with a treatable tropical infection.

Then there was the capsizing of his zodiac off Lords Cove on the Burin Peninsula of Newfoundland. He managed to hold onto the boat and showed up in the community in the early morning looking to rinse the engine with fresh water on a day when it was too rough for inshore fishermen to go fishing. There was the time another scientist aboard a fishing boat off Red Island in Placentia Bay came upon a radar target in thick fog. The first question was "Do you have shear pin for a 25 Johnson". It was Jon and a student in a zodiac – broke down.

Then there was Jon's trip to Toronto in the 1970s for a specialized procedure to repair and stabilize a collapsed lung. Just released from the hospital, he called Judy to wire money to Toronto because he wanted a goat breeder at the Royal Winter Fair to sell him some dairy goats. He succeeded in buying the goats, built the shipping crates himself to contain all 12, and hitched a ride in the cockpit with the pilots while they freighted the goats back to Newfoundland. And the stories could go on and on and on.

Lien Family Farm

Jon loved farming. When he and Judy bought their land in Portugal Cove, he immediately planted a garden, began working to improve the soil, and constructed the greenhouses that he knew would extend the short Newfoundland 60 day growing season. Over the years, he added a barn and paddock, a root cellar, a tractor shed, a cabin, and a two-storey chill building. He hauled thousands of bags of leaves, manure, and sawdust and dump truck loads of peat to create fertile ground. An organic inspector who certified farms from Ontario to Newfoundland declared that the soil at the Lien Family Farm was more productive per square foot than any other soil she'd ever seen.

The Lien family raised goats, chickens, turkeys, and pigs and produced more than 50 different crops for the Organic Veggie Co-op/Lien Farm Share CSAs supplying local families and a St. John's health food store. On Thanksgiving 2002, the Lien Family Farm celebrated its 30th anniversary. Today, the land is still worked organically by a group of young farmers who sell their produce in community shares.

FIGURE 3. Jon Lien recording data on dolphins.

Later Life

On 16 October 2002, Jon was involved in a truck accident that changed his life with a refocus on his personal health. Nevertheless, in 2003-2004 he helped to complete a study encouraging a sustainable lobster fishery in Eastport, Bonavista Bay. He determinedly helped with chores on the farm, and he sought out, purchased, and began working a tract of land in central Newfoundland.

Over the next few years, Jon's mobility became increasingly difficult and daily tasks became a challenge. Jon was hospitalized in 2007, requiring full-time nursing home care. Judy remained a steadfast companion until his death.

On Wednesday, 14 April 2010, at the age of 71, Jon died of heart complications. Jon was predeceased in death by his parents and sister Mary (Lien) Wilson. He is survived by his wife Judy (Traastad) Lien, sister Karin (Lien) Watson, brother Richard Lien, daughter Maren (Lien) Hinlopen, sons O. J. Lien and Elling Lien, and grandchildren Teya and Talia Hinlopen and Ellen Ann Lien.

Jon Lien's was a life well lived, well loved, and will not be forgotten.

Publications of Jon Lien 1967-2010

Lien, O. J. 1967. Some relations between suckling stereotypy, exploratory behaviour, and discrimination reversals in swine. Master's thesis. Washington State University.

Lien, J., and **H. Barbaree.** 1970. Prenatal patterned auditory stimulation and its effect on the post-hatch approach response in domestic chicken (Gallus gallus domesticus). Paper Presented to the Annual Meeting of the Canadian Psychological Association, Winnipeg, May 28.

Lien, J. 1971. The development of species recognition in avians. Paper presented at Department of Entomology, McGill University, March 30.

Martin, G., M. Parsons, and **J. Lien.** 1971. Control of sea gulls in city water reservoirs: a preliminary report submitted to the Clean Air, Water and Soil Authority, Government of Newfoundland, April 2.

Lien, J. 1972. Adjusted developmental rates in embryonogeny and embryo acoustic behaviour in several species of nidifugous birds. Dissertation Abstracts International.

Noseworthy, C., S. Stoker, and **J. Lien.** 1973. Habitat preferences in herring gull chicks. The Auk 90(1): 193–194.

Lien, J., and **G. J. Fitzgerald.** 1973. Several factors influencing web-spinning activity in the common house spider (Achaearanea tepidariorum Rech. Animal Learning and Behaviour 1(4): 290-292.

Lien, J. 1975. Aggression between Great Black-Backed Gulls and Bald Eagles. The Auk 92(3): 584–585.

Lien, J., and **M. Clements.** 1975. Effects of tactile stimulation on the initiation and maintenance of the following response in Japanese quail (*Coturnix coturnix japonica*). Animal Learning and Behavior 3(4): 301-304.

Clements, M., and **J. Lien.** 1976. Paired rotation and auditory stimulation of common murre *Uria aalge aalge* embryos and its posthatch effect. Behavioral Biology 17(3) 417–423.

Lien, J. 1976. Auditory stimulation of Coturnix embryos Coturnix coturnix japonica and its later effect on auditory preferences. Behavioral Biology 17(2): 231–235.

Noseworthy, C. M., and **J. Lien.** 1976. Ontogeny of nesting habitat recognition and preference in neonatal herring gull chicks, *Larus argentatus Pontoppidan*. Animal Behaviour 24(3): 637–651.

Lien, J., and **P. Redmond.** 1977. Recognition of conspecific vocalization by Coturnix chicks. Quail Quarterly: April.

Lien, J. 1977. Vocalization in Leach's storm petrel [abstract]. American Zoologist.

Lien, J. 1978. Red Island – A study in adaptation of gulls and people. The Osprey (Newfoundland Natural History Society Quarterly) 8(1): 41-47.

Lien, J. 1978. The ugly goatling. The Osprey (Newfoundland Natural History Society Quarterly) 9(3): 85-87.

Lien, J., and **L. Grimmer.** 1978. Manx shearwater breeding in Newfoundland. The Osprey (Newfoundland Natural History Society Quarterly) 9:50–54.

J. Lien, and **F. D. Klopfer.** 1978. Some relations between stereotyped suckling in piglets and exploratory behaviour and discrimination reversal learning in adult swine. Applied Animal Ethology 4(3): 223–233.

Lien, J. 1979. Whale collisions with fishing gear in Newfoundland. Report to the Minister's Committee on Whales and Whaling. Government of Canada.

Lien, J., S. Johnson, and **B. Merdsoy.** 1979. Whale distribution in Newfoundland during 1979. The Osprey 11(2): 21–32.

Lien, J., B. Merdsoy, and **A. Storey.** 1979. An extralimital record of a Narwhal (*Monodon monoceros*) in Hall's Bay Newfoundland. Canadian Field-Naturalist 93: 303-304.

Lien, J. 1979. Raising moose calves on dairy goats. Dairy Goat Guide (1): April

Lien, J., and **B. Merdsoy.** 1979. The humpback is not over the hump. Natural History, April: 46-49.

Lien, J. 1979. Doe mothered a moose nicely. Dairy Goat Guide, April.

Lien, J. 1980. Whale collisions with fishing gear in Newfoundland. Report to Fisheries and Oceans Canada — Newfoundland Region. 31 December 1980. 316 pages.

Lien, J. 1980. Cetaceans. Science 208(4441): 279–280.

Lien, J. 1980. Net loss. Nature Canada 9(3): 5-9.

Lien, J., and **W. E. Mercer.** 1980. Control of lynx predation on caribou calves by flavor illness aversions. *Edited by* E. Reimers, E. Gaare, and S. Skenneberg *in* International Reindeer/Caribou Symposium (2): 725-727.

Lien, J., S. Johnson, B. Davis, and **S. Gray.** 1981. Humpback whale collisions with inshore fishing gear. Preliminary report to Fisheries and Oceans Canada — Newfoundland Region, St. John's, Newfoundland.

Lien, J. 1981. The trouble with whales. Toronto: Greey de Pencier Books. (children's book)

Lien, J., and **N. Hennessey.** 1982. Whales of Newfoundland and Labrador. St. John's, Newfoundland: MUN Press.

Lien, J., and **D. Aldrich.** 1982. The basking shark (*Cetorhinus maximus*) in Newfoundland. Report to the Department of Fisheries, Government of Newfoundland and Labrador, St. John's, Newfoundland. 186 pages.

Lien J., J. H. Dong, L. Baraff, J. Harvey, and **K. Chu.** 1982. Whale entrapment in inshore fishing gear during 1982: A preliminary report to Fisheries and Oceans Canada, St. John's, Newfoundland. 36 pages.

Lien, J., S. Staniforth, L. Fawcett, R. Vaughan, and **D. J. Hai.** 1982. Whale and shark entrapments in inshore fishing gear during 1983. Report to Fisheries and Oceans Canada — Newfoundland Region.

Whitehead, H., and **J. Lien.** 1982. Changes in abundance of whales and whale damage along the Newfoundland coast 1973–1981. International Whaling Commission, Scientific Document SC/ 34/01.

Lien, J., and **H. Whitehead.** 1983. Changes in humpback (*Megaptera novaeangeliae*) abundance off NE Newfoundland related to the status of capelin (*Mallotus villosus*) stocks. *In* Proceedings of the Fifth Biennial Conference on the Biology of Marine Mammals. Boston, Massachusetts.

Lien, J., and **H. Whitehead.** 1984. Humpback abundance on NE Newfoundland, whale damage to fishing gear and variation in capelin stocks (1973-1983). *In* Marine Mammal/Commercial Fisheries Interactions in the SE Bering Sea. *Edited by* B. Meltoff.

Lien, J., L. Dix, E. Lee, and **H. Walter.** 1984. Whale and shark entrapments in inshore fishing gear during 1984. Report to Fisheries and Oceans Canada — Newfoundland Region.

Lien, J. (and others of the Whale Research Group). 1984. Getting along: fish, whales and fishermen. St. John's: Breakwater Books.

Lien, J. (and others of the Whale Research Group). 1984. Getting Along: Teacher's Guide. St. John's: Breakwater Books.

Lien, J. (and others of the Whale Research Group). 1984. Getting Along: Enrichment Kit Teacher's Guide. St. John's: Department of Education, Government of Nefoundland and Labrador.

Lien, J., L. Fawcett, and **S. Staniforth.** 1984. Whales and seals of Newfoundland and Labrador. St. John's: Breakwater Books.

Lien, J. 1985. Incidental catches of harp seal by inshore fishermen in Newfoundland. Royal Commission on Seals and the Sealing Industry in Canada. 3 pages.

Lein, J. 1985. Incidental occurrence and catches of Leatherback Turtles in Newfoundland (1979–1985). Report to Fisheries and Oceans Canada. 5 pages.

Lein, J. 1985. Review of the preliminary management plan of the Avalon Wilderness Area. Wilderness and Ecological Reserves Advisory Council. Government of Newfoundland and Labrador. 8 pages.

Lein, J. 1985. Review of the management proposal for Mistaken Point. Wilderness and Ecological Reserves Advisory Council, Government of Newfoundland and Labrador. 8 pages.

Lein, J. 1985. Review of the management proposal for "The Grass." Wilderness and Ecological Reserves Advisory Council, Government of Newfoundland and Labrador. 3 pages.

Lein, J. 1985. Review of the management proposal for King George IV Lake Delta. Wilderness and Ecological Reserves Advisory Council, Government of Newfoundland and Labrador. 5 pages.

Lein, J. 1985. Review of the management proposal for the Avalon Wilderness Area. Wilderness and Ecological Reserves Advisory Council, Government of Newfoundland and Labrador. 6 pages.

Lien, J., J. Au, J. Connley, S. Greening, and **B. Stirling.** 1985. Attitudes toward the environment and their implications for wilderness preservation in Newfoundland. Park News 21(4): 8-13.

Lien, J., and **L. Fawcett.** 1985. A contribution to the biology of the basking shark (*Cetorhinus maximus*) in waters off Newfoundland. Canadian Field-Naturalist 100: 246–252.

Lien, J., L. Fawcett, and **S. Staniforth.** 1985. Teaching fishermen about whales: The role of education in conservation and fisheries management problems. *In* Marine Parks and Conservation, Volume 1. *Edited by* J. Lien. and R. Graham. National and Provincial Parks Association of Canada, Toronto, Ontario.

Lien, J., and **R. Graham.** 1985. An introduction to marine parks and conservation. *In* Marine Parks and Conservation, Volume 1. *Edited by* J. Lien and R. Graham. National and Provincial Parks Association of Canada, Toronto, Ontario.

Lien, J., D. Snow, G. B. Stenson, and **R. Elliot.** 1985. Incidental entrapment of whales, seals, and seabirds in inshore fishing gear in Newfoundland and Labrador: A problem for fishermen and fishing gear designers. World Symposium on Fishing Gear and Fishing Vessel Design, November 21–24, St. John's, Newfoundland.

Lien, J., S. Staniforth, and **L. Fawcett.** 1985. Teaching fishermen about whales: The role of education in conservation and fisheries management problems. In Marine Parks and Conservation, Volume 1. *Edited by* J. Lien and R. Graham. National and Provincial Parks Association of Canada, Toronto, Ontario.

Lien J., G. B. Stenson, and **I. Hsun Ni.** 1985. A review of incidental entrapment of whales, seals and seabirds in inshore fishing gear in Newfoundland and Labrador: A problem for fishermen and fishing gear designers. World Symposium on Fishing Gear and Fishing Vessel Design, November 21–24, St. John's, Newfoundland.

Lien, J., and H. Walter. 1985. An investigation of the potential role of education in managing marine resource conflicts: Volume I. Report to Communications Directorate, Fisheries and Oceans Canada. 530 pages.

Lien, J. 1985. Marine education in Canada: An investigation of the potential role of education in managing marine resource conflicts. Volume 1, Final Report to the Department of Fisheries and Oceans, Contract Number 0ST84-00119, Ottawa.

Lien, J., H. Walter, and **C. Harvey-Clark.** 1985. Whale and shark entrapments in inshore fishing gear during 1985. Report to Fisheries and Oceans Canada—Newfoundland Region and the Newfoundland and Labrador Department of Fisheries. 21 pages.

Storey, A. E., and **J. Lien.** 1985. Development of the first North American colony of Manx Shearwaters. Auk 102(2): 395–401.

Walter, H., and **J. Lien.** 1985. Knowledge and attitudes of Canadian students and teachers towards the marine environment and marine education. *In* Marine Parks and Conservation, Volume 1. *Edited by* J. Lien and R. Graham. National and Provincial Parks Association of Canada, Toronto, Ontario.

Lien, J. 1985. Managing Whale / Fishermen conflicts. In proceedings of the whale entrapment workshop, National Marine Fisheries Service, San Padro, California.

Lien, J., and **R. Graham.** *Editors.* 1985. Marine parks and conservation: challenge and promise, Volume 1: Issues. Harkin Park book series number 10. Toronto: National and Provincial Parks Association of Canada.

Lien, J., and **R. Graham.** *Editors.* 1985. Marine parks and conservation: challenge and promise, Volume 2: International experience. Harkin Park book series no. 11. Toronto: National and Provincial Parks Association of Canada.

Lien, J., and **R. Graham.** *Editors.* 1986. Marine parks and conservation: challenge and promise, Volume 3: International experience. Harkin Park book series number 12. Toronto: National and Provincial Parks Association of Canada.

Dix, L., J. Lien, and **D. E. Sergeant.** 1986. A North Sea Beaked Whale (*Mesoplodon bidens*) in Conception Bay, Newfoundland. Canadian Field-Naturalist 100: 389–391.

Lien, J. 1986. Teaching fishermen about whales. Whalewatcher 20:3–7.

Lien, J. 1986 Social science and conservation perspectives in integrated forest land use. The Forester 22(3): 1986.

Lien, J. 1986. Prescribed and optional environmental education in provincial curriculum guides. Report to the Canadian Nature Federation. 4 pages.

Lien, J. 1986. Blue whales stranded due to ice on Newfoundland's southwest coast (1978–1986). Fisheries and Oceans Canada. 11 pages.

Lien, J., and **K. Breeck.** 1986. Marine mammal sightings on the *Gadus Atlantica*, 13 May–2 June, 1986. Fisheries and Oceans Canada. 11 pages.

Lien, J., K. Breeck, D. Pinsent, and **H. Walter.** 1986. Whale and shark entrapments in inshore fishing gear during 1986. Report to Fisheries and Oceans Canada — Newfoundland Region. 26 pages.

Lien, J., and **L. Fawcett.** 1986. Distribution of Basking Sharks (*Cetorhinus maximus*) incidentally caught in inshore

fishing gear in Newfoundland. Canadian Field-Naturalist 100: 246-252.

Lien, J., and **D. Pinsent.** 1986. Whale abundance in standard transects on Newfoundland's northeast coast during 1986. Fisheries and Oceans Canada 8 pages.

Lien, J. 1986. Review of "The war against the seals, a history of the North American Seal Fishery" by Briton Cooper Bushe in The American Review of Canadian Studies.

Lien, J., and **H. Walter.** 1986. Life along the edge: where land and sea interact. Teacher's guide for grade 4-6 curricula. Ottawa: Parks Canada.

Lien, J. 1987. Vocalizations in humpback whales when they're all alone. Abstracts of the Seventh Biennial Conference on the Biology of Marine Mammals, Society for Marine Mammalogy.

Lien, J. 1987. Can we teach everybody to feel the same way about whales? Abstracts of the Seventh Biennial Conference on the Biology of Marine Mammals, Society for Marine Mammalogy.

Lien, J., and **K. Breeck.** 1987. Cetacean strandings in Newfoundland and Labrador and geomagnetic characteristics of stranding locations. North Atlantic Marine Mammal Association Proceedings of Meetings, NAMMA, Provincetown, Mass.

Lien, J., K. Breeck, D. Pinset, and **H. Walter.** 1987. Humpback whale collisions with inshore fishing gear in Newfoundland and Labrador (1978–1986). North Atlantic Marine Mammal Association Proceedings of Meetings, NAMMA, Provincetown, Mass.

Lien, J., K. Breeck, and **G. B. Stenson.** 1987. A mass stranding of Sowerby's beaked whales *(Mesoplodon bidens*) in Newfoundland. North Atlantic Marine Mammal Association Proceedings of Meetings, NAMMA, Provincetown, Mass.

Lien, J., B. Brown, J. Dodd, and **H. Walter.** 1987. Cultural relativism and the management of whales. North Atlantic Marine Mammal Association Proceedings of Meetings, NAMMA, Provincetown, Massachusetts.

Lien, J., I. Christensen, and **M. Lien.** 1987. Observations on the identification of Killer Whales (*Orcinus orca*) in the Lofoton Islands area of Norway. Report to Hubbs Marine Research Center and I.W.C. Orca Workshop. NAKW/87/04. 11 pages.

Lien, J., J. Papineau, and **L. Dugan.** 1987. Incidental entrapments of cetaceans, sharks, and marine turtles in inshore fishing gear reported during 1987 in Newfoundland and Labrador. Report to Fisheries and Oceans Canada—Newfoundland Region and the Newfoundland and Labrador Department of Fisheries. 25 pages.

Lien, J., and **R. Sears.** 1987. Whales and fishermen. Proceedings of the World's Whales Workshop, American Cetacean Society, San Pedro, California.

Lien, J., G. B. Stenson, S. Booth, and **R. Sears.** 1987. Ice entrapments of blue whales (*Balaenoptera musculus*) in Newfoundland and Labrador (1978–1987). Abstracts from the North Atlantic Marine Mammal Association Conference, March 26–27, 1987, Boston, Massachusetts.

Lien, J., G. B. Stenson, and **P. Jones.** 1987. Orca in waters off Newfoundland and Labrador. Report to Hubbs Marine Research Center and I.W.C. Orca Workshop. NAKW/87/11. 19 pages.

Kirkham, I. R., W. A. Montevecchi, O. J. Lien, B. O. Sklepkovych, and **R. J. Butler.** 1987. Damage to Leach's Storm-petrel feet. Ornis Scandinavica 18(1): 61–64.

Goff, G. P., and **J. Lien.** 1988. Atlantic Leatherback Turtles, *Dermochelys coriacea,* in cold water off Newfoundland and Labrador. Canadian Field Naturalist 102 (1):1–5.

Lien, J. 1988. A review of the West Isles feasibility study: A study to assess the feasibility of establishing a National Marine Park in the West Isles area of the Bay of Fundy, New Brunswick. Environment Canada—Canadian Parks Service.

Lien, J. 1988. Entrapment assistance program review. Report submitted to the Program Review Committee, Minister's Advisory Committee on Whales and Whaling, Department of Fisheries and Oceans. 6 pages.

Lien, J. 1988. How, when and why to involve fishermen in the park management process. Proceedings of the Workshop on National Marine Park Planning, Hull, Quebec, 23–25 February, Parks Canada, Hull, Quebec. Pages 36–49.

Lien, J. 1988. Lessons from whales and fishermen about marine parks. Pages 36-39 *in* Occasional Paper 8, Marine, Lake and Coastal Heritage. *Edited by* R.Graham. Heritage Resources Centre, University of Waterloo, Waterloo, Ontario,

Lien, J. 1988. Problems of Newfoundland fishermen with large whales and sharks during 1987 and a review of incidental entrapment in inshore fishing gear during the past decade. The Osprey 19(1): 30-38 and 19(2): 65-72.

Lien, J. 1988. Great Barrier Reef wonderland: A review of the Great Barrier Reef Marine Park Authority's aquarium. Great Barrier Reef Marine Park Authority, Townsville, Australia. 21 pages.

Lien, J., and **J. Atkinson.** 1988. Education programmes about whales. Pages 160-169 *in* The World's Whales: A Closer look. Selected Papers of the Third Biennial Conference and Symposium, Monterey, California, 11–13 November1988.

Lien, J. 1988. Canadian lobster fishermen reap the benefits of marine reserves. Waves 5(3): 16.

Lien, J., I. Christensen, M. Lien, and **P. Jones.** 1988. A note on Killer whales (*Orcinus orca*) near Svolvær, Lofoten Islands, Norway, in November-December 1984. Rit Fiskideildar 11: 95–98.

Lien, J., W. Ledwell, and **J. Naven.** 1988. Incidental entrapments in inshore fishing gear during 1988; Report to the Newfoundland and Labrador Department of Fisheries and Oceans Canada—Newfoundland Region and the Newfoundland and Labrador Department of Fisheries. 38 pages.

Lien, J., and **D. Snow.** 1988. A new record of a white shark in Newfoundland. The Osprey 19(2): 12–15.

Lien, J., and **D. Snow.** 1988. Bay du Nord Wilderness. Borealis 1(1): 31–35.

Lien, J., G. B. Stenson, and **I.-H. Ni.** 1988. A review of incidental entrapment of seabirds, seals, and whales in inshore fishing gear in Newfoundland and Labrador: A problem for fishermen and fishing gear designers. Proceedings of the 1988 World Symposium on Fishing Gear and Fishing Vessel Design. Newfoundland and Labrabdor Institute of Fisheries and Marine Technology, St. Johns's. Newfoundland. Pages 67–71.

Lien, J., G. B. Stenson, and **P. W. Jones.** 1988. Killer whales (*Orcinus orca*) in waters off Newfoundland and Labrador, 1978–1986. Rit Fiskideildar 11: 194–201.

Árnason, Ú., P. W. Allderdice, J. Lien, and **B. Widegren.** 1988. Highly repetitive DNA in the baleen whale genera Balaenoptera and Megaptera. Journal of Molecular Evolution 27: 217–221.

Muir, D. C. G., R. Wagemann, N. P. Grift, R. J. Norstrom, M. Simon, and **J. Lien.** 1988. Organochlorine and heavy metal contaminants in white-beaked dolphins *(Lagenorhynchus albirostris)* and pilot whales (*Globicephala melaena*) from the coast of Newfoundland, Canada. Archives of Environment Contamination and Toxicology 17: 613–629.

Lien, J. 1989. Incidental catches of Harbour Porpoise (*Phocoena phocoena*) in waters off Newfoundland and Labrador: Some estimates based on present data and a request for further study. Special Workshop on Harbour Porpoise, St. Andrews, New Brunswick. 8 pages.

Lien, J. 1989. Lessons about whale management. Proceedings of the 5th International Conference on the Relationships Between Humans and Animals, AFRIC, Paris.

Lien, J. 1989. Marine education in Canada – Lessons for marine educators. Pages 1-8 *in* Proceedings of Splash '89 – Marine interpretation. Ocean Sciences Centre, Memorial University of Newfoundland, St. John's.

Lien, J. 1989. Eau Canada! A new marine-parks system. Pages 107-119 *in* Endangered Spaces: The Future For Canada's Wilderness. *Edited by* M. Hummel. Key Porter Books, Toronto, Ontario.

Lien, J. 1989. Eau Canada! How much we have to learn. Pages 1-11 *in* Interpreting our marine and freshwater heritage. *Edited by* H. Griffin. Interpretation Canada, Ottawa, Ontario.

Lien, J., and **F. Barry.** 1989. COSWEIC status report on the Sowerby's beaked whale, Mesoplodon bidens, in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. 20 pages.

Lien, J., and **S. Katona.** 1989. A guide to the photographic identification of individual whales based on their natural and acquired Markings. American Cetacean Society and Breakwater Books, San Pedro, California. 78 pages.

Lien, J., W. Ledwell, and **J. Huntington.** 1989. Incidental entrapments in inshore fishing gear reported in 1989. Report to the Department of Fisheries and Oceans—Newfoundland Region and the Newfoundland and Labrador Department of Fisheries. 33 pages.

Lien, J., and **P. Parsons.** 1989. Working with fishermen and whales. Sonar, 3–7.

Lien, J., and **A. Ross.** 1989. You oughta be in pictures: Media, marine mammals and mammalogists. North Atlantic Marine Mammal Association Newsletter, Fall, 1989.

Lien, J., R. Sears, G. B. Stenson, P. W. Jones, and **I.-H. Ni.** 1989. Right whale, *Eubalaena glacialis*, sightings in waters off Newfoundland and Labrador and the Gulf of St. Lawrence, 1978–1987. Canadian Field-Naturalist 103(1): 91–93.

Lien, J., G. B. Stenson, S. Todd, and **I.-H. Ni.** 1989. Incidental catches of marine mammals in inshore waters of Newfoundland and Labrador (1979–1989). Abstracts of the 8th Biennial Conference on the Biology of Marine Mammals. 7–11 December, Pacific Grove, California. Page 38.

Lien, J., and **W. Ledwell.** 1989. Continued Development of the First North American Colony of Manx Shearwaters. The Natural History Society of Newfoundland and Labrador, The Osprey 20(3), September.1989, St. John's, Newfoundland.

Harrigan-Ostrom, P., J. Lien, and **S.A. Mako.** 1989. Trophic position, feeding habits, and distribution in the Northwest Atlantic of Sowerby's beaked whale, *Mesoploden bidens*, obtained from carbon and nitrogen isotope data. Abstracts of the 8th Biennial Conference on the Biology of Marine Mammals. 7–11 December, Pacific Grove, California.

Bose, N., and **J. Lien.** 1989. Propulsion of a fin whale (*Balaenoptera physalus*): Why the fin whale is a fast swimmer. Proceedings of the Royal Society of London. Series B, Biological Sciences 237(1287), 175–200.

Bose, N., and **J. Lien.** 1989. A free ride for cetaceans. Abstracts of the 8th Biennial Conference on the Biology of Marine Mammals, 7–11 December, Pacific Grove, California.

Ross, A., and **J. Lien.** 1989. Ice-entrapped whales: A preliminary analysis of media impact on attitudes and knowledge. Proceedings of the Fifth International Conference on the Relationship Between Humans and Animals, AFRIC, Paris.

Ross, A., and J. Lien. 1989. Ice-entrapped gray whales off Barrows, Alaska: An analysis of media impact on management of cetaceans and public attitudes and knowledge. Abstracts of the 8th Biennial Conference on the Biology of Marine Mammals, 7–11 December, Pacific Grove, California.

Ross, A., J. Lien, and **P. Parsons.** 1989. Why people like whales. Whalewatcher: Journal of the American Cetacean Society, 23(3) 21–23.

Guigné, J. Y., J. Lien, J. A. Guzzwell, and **A. Smith.** 1990. Development of acoustic protection for fixed fishing gear to minimize incidental catches of marine mammals. Second Interim Progress Report for the …, 1990/

Lien, J. 1990. A review of the educational benefits of the Great Barrier Reef Aquarium, Report to the Great Barrier Reef Marine Park Authority, Townsville, Queensland, Australia.

Lien, J. 1990. The inshore cod fishery of Newfoundland and Labrador, Visions 2020, Public Focus, Toronto, Ontario, 27–32.

Lien, J. 1990. Whales of Labrador: Then and now. *In* Euskaldunen Labrador, de los vascos, des basques. *Edited by* Xabi Otero. Navarre: Txoria Errekan.

Lien, J. 1990. Whaling in the North Atlantic. Report to the Newfoundland and Labrador Department of Fisheries. 10 pages.

Lien, J. 1990. Review of the adequacy of the environmental impact assessment study for the Goose Bay NATO Base, with particular reference to impacts on marine mammals. 15 pages.

Lien, J., and **F. Barry.** 1990. Status of Sowerby's beaked whale, *Mesoplodon bidens*, in Canada. Canadian Field-Naturalist 104(1): 125–130.

Lien, J., F. Barry, K. Breeck, and **U. Zuschlag.** 1990. Multiple strandings of Sowerby's beaked whales, *Mesoplodon bidens*, in Newfoundland. Canadian Field-Naturalist 104(3): 414–420.

Lien, J., J. Huntington, W. Ledwell, and **T. Huntsman.** 1990. Whale entrapments in inshore fishing gear and a summary of the entrapment assistance program in Newfoundland and Labrador during 1990. Report to Fisheries and Oceans Canada—Newfoundland Region and the Newfoundland and Labrador Department of Fisheries. 36 pages.

Lien, J., and **S. Katona.** 1990. A guide to the photographic identification of individual whales based on their natural and acquired markings. Breakwater Books, St. John's, Newfoundland.

Lien, J., G. B. Stenson, and **P. W. Jones.** 1990. A natural trap for blue whales *Balaenoptera musculus*: Sightings and ice entrapments in Newfoundland (1979-1988). Unpublished manuscript.

Lien, J., S. Todd, and **J. Guigné.** 1990. Inferences about perception in large cetaceans, especially humpback whales,

from incidental catches in fixed fishing gear, enhancement of nets by "alarm" devices, and the acoustics of fishing gear. Pages 347-362 *in* Sensory Abilities of Cetaceans, *Edited by* J. Thomas and R. Kastelein. Plenum Press, New York..

Beard, J., P. Clapham, P. Hammond, S. Katona, F. Larson, J. Lien, D. Matilla, C. Mayo, N. Oien, P. Palsbol, T. Polacheck, J. Sigurjonsson, and **T. Smith.** 1990. YoNAH: Years of the North Atlantic Humpback Whale. International Whaling Commission, Scientific Committee. IWC/SC42/02. The Hague, Holland. 10 pages.

Bose, N., J. Lien, and **J. Ahia.** 1990. Measurements of the bodies and flukes of several cetacean species. Proceedings of the Royal Society of London. Series B, Biological Sciences 242(1305): 163–173.

Bose, N., and **J. Lien.** 1990. Energy absorption from ocean waves: A free ride for cetaceans. Proceedings of the Royal Society of London. Series B, Biological Sciences 240: 591–605.

Lien, J. 1991. The tragic tale of two marine parks. Borealis 2(3): 42–47.

Brennen, K. R., V. E. Baker, and **J. Lien.** 1991. A system for the transcutaneous recording of the cetacean electrocardiogram. Abstracts of the Ninth Biennial Conference on the Biology of Marine Mammals, Marine Mammal Society, Chicago, Illinois, 10.

Curren, K. C., N. Bose, and **J. Lien.** 1991. Use of track and wave data to determine possible wave energy absorption for whale propulsion. Abstracts of the Ninth Biennial Conference on the Biology of Marine Mammals, Marine Mammal Society, Chicago, Illinois l6.

Curren, K. C., N. Bose, and **J. Lien.** 1991. Do whales extract energy from ocean waves? Joutnal of the Marine Biology. Association of the U.K. 71(3): 733.

Nelson, D. L., and **J. Lien.** 1991. Behaviours of two Atlantic white-sided dolphins *(Lagenorhynchus acutus)* and their responses to objects. Abstracts of the Ninth Biennial Conference on the Biology of Marine Mammals, Marine Mammal Society, Chicago, Illinois 49.

Ostrom, P. H., S. A. Macko, and **J Lien.** 1991. An isotopic record from known age baleen. Abstracts of the Ninth Biennial Conference on the Biology of Marine Mammals, Marine Mammal Society, Chicago, Illinois 51.

Todd, S.K., J. Lien, and **J. Y. Guigne.** 1991. The acoustics of fishing gear: Implications for humpback whale entrapments in Newfoundland and Labrador. Abstracts of the Ninth Biennial Conference on the Biology of Marine Mammals, Marine Mammal Society, Chicago, Illinois 68.

Lien, J. 1991. A bibliography of selection and design criteria for protected natural areas. Report to the Protected Areas Association, St. John's, Newfoundland. 50 pages.

Lien, J., W. Barney, A. Verhulst, R. Seton, and **S. Todd.** 1991. Entrapments and strandings reported to the Entrapment Assistance Program during 1991. Report to the Department of Fisheries and Oceans — Newfoundland Region and the Newfoundland and Labrador Department of Fisheries. 29 pages.

Lien, J., R. Seton, and **S. Todd.** 1991. The impact of tour boats in the Witless Bay Ecological Reserve. Report to the Marine Adventures Association. 69 pages.

Lien, J., W. Barney, S. Todd, R. Seton, and **J. Guzzwell.** 1991. Tests of "whale alerts" on codtraps. Report to the Centre for Fisheries Innovation, St. John's, Newfoundland. 35 pages.

Lien, J., S. Todd, and **J. Guigné.** 1991. Inferences about perception in large cetaceans, especially humpback whales, from incidental catches in fixed fishing gear, enhancement of nets by "alarm" devices, and the acoustics of fishing gear. Pages 347–362 *in* Sensory Abilities in Cetaceans: Laboratory and Field Evidence. *Edited by* J. Thomas and R. Kastelein. Plenum Press, New York..

Nelson, D., A. Desbrosse, J. Lien, P. Ostrum, and R. Seton. 1991. A new stranding record of the pygmy sperm whale, *Kogia breviceps*, in waters off eastern Canada. Canadian Field-Naturalist 105(3): 407–408.

Nelson, D., and **J. Lien.** 1991. Status of the Long-finned Pilot Whale (*Globicephla melas*) in Canada. Report to Committee on the Status of Endangered Wildlife in Canada, Environment Canada, Ottawa.

Nelson, D., and **J. Lien.** 1991. Status of the White-beaked Dolphin in Canada. Report to Committee on the Status of Endangered Wildlife in Canada, Environment Canada, Ottawa.

Nelson, D., and **J. Lien.** 1991. Status of the northwestern Atlantic stock of Long-finned Pilot Whales. International Council for the Exploration of the Sea. Document WPl/91.

Lien, J. 1991. Occasional Paper 15 *in* Marine, Lake and Coastal Heritage. *Edited by* Robert Graham. http://www.fes.uwaterloo.ca/research/hrc/research/documents/HRC_Consolidated_publication_list_2007.doc

Lien, J. 1992. Whales, fishermen and marine parks: Attitudes toward conserving and managing our ocean's resources. Pages 1-19 *in* Marine, Lake and Coastal Heritage, *Edited by* R. Graham. University of Waterloo Heritage Resources Centre, Waterloo, Ontario.

Lien, J. 1992. Eau Canada: Educating for change. Green Teacher (29) 15–16.

Lien, J. 1992. Need hands-on access to large whales? Report to the Office of Naval Research and National Marine Fisheries Service Workshop on Tagging and Tracking of Cetaceans. Arlie Foundation. 15 pages.

Lien, J., W. Barney, W. Ledwell, S. Todd, and **K. Curren.** 1992. Entrapments and strandings reported to the Entrapment Assistance Program during 1992. A preliminary report to the Department of Fisheries and Oceans and the Newfoundland and Labrador Department of Fisheries. 24 pages.

Lien, J., W. Barney, S. Todd, R. Seton, and **J. Guzzwell.** 1992. The effects of adding sounds to codtraps on the probability of collisions by humpback whales. Páges 701–708 *in* Marine Mammal Sensory Systems, *Edited by* J. A. Thomas, R. A., Kastelein, and A. Y. Supin. Plenum Press, New York.

Lien, J., J. Guigné, and **S. Todd.** 1992. Acoustical redesign of fixed nets and traps to minimize incidental catches of marine animals. Proceedings of the World Fisheries Congress, page 46.

Lien, J., D. Nelson, S. Todd, and **R. Seton.** 1992. A program to minimize whale mortality and damage to fishing gear: Incidental catches of large whales in Newfoundland and Labrador. Proceedings of the World Fisheries Congress.

Lien, J., R. Seton, and **S. Todd.** 1992. Impact of tour boats in the Witless Bay Ecological Reserve on whales, seabirds, and people. A report to the Atlantic Canada Opportunities Agency and the Marine Adventures Association of Newfoundland and Labrador. 42 pages.

Lien, J., S. Todd, K. Curren, and **R. Seton.** 1992. The impact of tour boat activity on humpback whales and seabirds in the Witless Bay Ecological Reserve, Newfoundland, and effects of tour boat experiences on passengers. Report to the Marine Adventures Association and Atlantic Canada Opportunities Agency, St. John's, Newfoundland. 62 pages.

Nelson, D., and **J. Lien.** 1992. A review of gear and animal characteristics responsible for incidental catches of cetaceans in fishing gear, along with proposed solutions. Proceedings of the World Fisheries Congress, Athens, Greece, May 3–8, 1992.

Ostrom, P. H., J. Lien, and **S. A. Macko.** 1992. Evaluation of the diet of Sowerby's beaked whale, *Mesoplodon bidens*, based on isotopic comparisons among northwestern Atlantic cetaceans. Canadian Journal of Zoology 71: 858–861.

Seton, R., J. Lien, D. Nelson, and **P. Hann.** 1992. A winter survey of marine mammals and birds on the south coast of Newfoundland. Report to the Atlantic Canada Opportunities Agency, Canadian Wildlife Service, and the Department of Fisheries and Oceans. 94 pages.

Seton, R., J. Lien, D. Nelson, and **P. Hann.** 1992. A survey of Blue Whales (*Balaenoptera musculus*), other cetaceans, seals, and marine birds on the south coast of Newfoundland, March 1992. Whale Research Group, Memorial University of Newfoundland. 68 pages.

Todd, S., J. Lien, and **A. Verhulst.** 1992. Orientation of humpback whales (*Megaptera novaengliae*) and minke whales (*Balaenoptera acutorostrata*) to acoustic alarm devices designed to reduce entrapment in fishing gear. Pages 727–739 *in* Marine Mammal Sensory Systems. *Edited by* J. A. Thomas, R. A. Kastelein, and A. Y. Supin. Plenum Press, New York.

Allen, J., P. Clapham, P. Hammond, S. Katona, F. Larsen, J. Lien, D. Mattila, N. Øien, P. Palsbøll, J. Sigurjonsson, and **T. Smith.** 1993. Years of the North Atlantic Humpback (YoNAH): Progress report. International Whaling Commission unpublished document SC/45/NA6.

Baker, C. S., A. Perry, J. L. Bannister, M. T. Weinrich, R. B. Abernethy, J. Calambokidis, J. Lien, R. H. Lambersen, J. Urbán Ramírez, O. Vasquez, P. J. Clapham, A. Alling, S. J. O'Brien, and **S. R. Palumbi.** 1993. Abundant mitochondrial DNA variation and world-wide population structure in humpback whales. Proceedings of the National Academy of Science USA 90: 8239–8243.

Curren, K., N. Bose, and **J. Lien.** 1993. Morphological variation in the harbour porpoise, (*Phocoena phocoena*). Canadian Journal of Zoology 71: 1067–1070.

Ketten, D. R., J. Lien, and **S. Todd.** 1993. Blast injury in humpback whale ears: Evidence and implications. Journal of the Acoustical Society of America 94(3): 1849–1850.

Lien, J. 1993. Student attitudes and how they are influenced. *In* Biology education and animals: Opportunities and issues. *Edited by* A. N. Rowan, and J. C. Weer. Tufts Center for Animals and Public Policy, Tufts University Press, North Grafton, Massachusetts.

Lien, J. 1993. A strategy for non-governmental organization involvement in the United Nations conference on highly migratory species and straddling stocks. Report to the Department of External Affairs and Fisheries and Oceans. 12 pages.

Lien, J. 1993. Fisheries Resource Conservation Council relations with non-traditional non-governmental organization interest groups. Report to the Fisheries Resource Conservation Council. 17 pages.

Lien, J., W. Barney, W. Ledwell, S. Stodd, P. Stevick, J. Huntingdon, R. Seton, and **K. Curren.** 1993. Incidental entrapments of marine mammals by inshore fishing gear reported in 1992, some result of bycatch monitoring, and tests of acoustic deterrents to prevent whale collisions in fishing gear. Report to Fisheries and Oceans Canada — Newfoundland Region and the Newfoundland Labrador Department of Fisheries.

Lien, J., S. Todd, P. Stevick, F. Marques, and **D. Ketten.** 1993. The reaction of humpback whales to underwater explosions: Orientation, movements, and behaviour. Journal of the Acoustical Society of America 94(3): 1849.

Ostrom, P. H., J. Lien, and **S. Macko.** 1993. Evaluation of the diet of Sowerby's beaked whale, *Mesoplodon bidens*, based on isotopic comparisons among northwestern Atlantic cetaceans. Canadian Journal of Zoology 71: 858–861.

Volgenau, L., S. D. Kraus, and **J. Lien.** 1993. The impact of fishing gear entanglements on two substocks of the western north Atlantic humpback whale (*Megaptera novaeangliae*). Abstracts of the Tenth Biennial Conference on the Biology of Marine Mammals, Society for Marine Mammology 109.

Lien, J. 1993. Vessel-based education enrichment. Concept paper for the Council on Marine Education and the Newfoundland and Labrador Department of Education. 4 pages.

Baker, C. S., R. W. Slade, J. L. Bannister, R. B. Abernethy, M. T. Weinrich, J. Lien, R. Urban, P. Corkerton, J. Calmabokidis, O. Vasques, and **S. R. Palumbi.** 1994. Hierarchical structure of mitochondrial DNA gene flow among humpback whales, *Megaptera novaeangliae*, world-wide. Molecular Ecology 3(4):313–327.

Goff, G. P., J. Lien, G. B. Stenson, and **J. Fretey.** 1994. The migration of a tagged leatherback turtle, *Dermochelys coriacea*, from French Guiana, South America, to Newfoundland Canada in 128 days. Canadian Field-Naturalist 108(1): 72-73.

Lien, J. 1994. Entrapments of large cetaceans in passive inshore fishing gear in Newfoundland and Labrador (1979–1990). *In:* Gillnets and Cetaceans. *Edited by* W. F. Perrin, G.P. Donovan, and J. Barlow. International Whaling Commission Special Issue 15: 149–157.

Lien, J. 1994. Social and ethical responsibilities of scientists. The Scientist (12) 13.

Lien, J. 1994. Experiments to reduce the incidental capture of Harbour Porpoise in groundfish gillnets in Grand Manan, Bay of Fundy. Report to the Department of Fisheries and Aquaculture, the Government of New Brunswick, and the Department of Fisheries and Oceans—Scotia-Fundy Region. 20 pages.

Lien J., and **C. Hood.** 1994. An investigation of acoustic devices to prevent harbour porpoise by-catch in groundfish gillnets, and recommendations from fishermen in the Bay of Fundy for future by-catch mitigation. Report to the Department of Fisheries and Aquaculture, Fredericton, New Brunswick, and the Department of Fisheries and Oceans, Halifax, Nova Scotia.

Lien, J., and **D. Nelson.** 1994. The status of long-finned pilot whales in Canada. Report to International Council for the Exploration of the Sea. 9 pages.

Lien, J., D. Pittman, and **D. Mitchell.** 1994. Entrapments and strandings of cetaceans in Newfoundland and Labrador during 1993. Report to the Department of Fisheries and Oceans. 28 pages.

Lien, J., G. B. Stenson, S. Carver, S., and **J. Chardine.** 1994. How many did you catch? The effect of methodology on bycatch reports obtained from fishermen. Pages 535–540 *in* Gillnets and Cetaceans. *Edited by* G. Donovan, W.F. Perrin, and J. Barlow. International Whaling Commission Special Issue 15.

Nelson, D., and **J. Lien.** 1994. Behaviour patterns of two captive Atlantic white-sided dolphins, *Lagenorhynchus acutus*. Aquatic Mammals 20(1): 1–10.

Nelson, D., and **J. Lien.** 1994. Responses of naive, captive dolphins to prototype whale alarms. Pages 621-622 *in* Gillnets and Cetaceans. *Edited by* W. Perrin, G. Donavan, and J. Barlow. International Whaling Commission Special Issue 15.

Shackell, N. L., and **J. Lien.** 1995. An under-utilized conservation option for fishery managers: Marine protected areas in the North-west Atlantic. Pages 21-30 *in* Proceedings of the Symposium on Marine Protected Areas and Sustainable Fisheries. *Edited by* N. L. Shackell and J. H. M. Willison. Second International Conference on Science and the Management of Protected Areas, Dalhousie University, Halifax, Nova Scotia. 16–20 May 1994.

Borggaard, D., and **J. Lien.** 1995. Reactions of individually-identified humpback whales to different types of industrial activity. Abstracts of the Eleventh Biennial Conference on the Biology of Marine Mammals, Marine Mammal Society 14.

Hood, C., J. Lien, and **P. Y. Daoust.** 1995. Lapsed time since death in harbour porpoise incidentally caught in groundfish gillnets. Abstracts of the Eleventh Biennial Conference on the Biology of Marine Mammals, Marine Mammal Society, 55.

Kastelein, R. A., A. D. Goodson, J. Lien, and **D. de Haan.** 1995. The effects of acoustic alarms on harbour porpoise (*Phocoena phocoena*) behaviour. Pages 157-167 *in* Harbour porpoises: Laboratory studies to reduce bycatch. P. E. Nachtigall,W.W.L. Au, J. Lien, and A. Read. De Spiel Publishers, Woerden, The Netherlands.

Lien, J. 1995. The role of environmental NGO's in the U.N. Conference on Straddling Fish Stocks and Highly Migratory Species. *In* Proceedings of the Workshop on the U.N. Straddling Stocks Conference. Memorial University of Newfoundland, St. John's, Newfoundland.

Lien, J. 1995. Conservation aspects of fishing gear: Cetaceans and gillnets. Pages 219–224 *in* Solving bycatch: Considerations for today and tomorrow. *Edited by* R. Dorfman and N. S. Dorfman. Alaska Sea Grant College Program Report Number 96-03, University of Alaska, Fairbanks.

Lien, J., and **C. Hood.** 1995. Treating fishermen as people: An effective approach to solutions of whale by-catch problems. Sixth International Symposium on Society and Resource Management, University Park, Pennsylvania, Pennsylvania State University.

Lien, J., C. Hood, D. Pittman, P. Ruel, D. Borggaard, C. Chisholm, L. Wiesner, T. Mahon, and **D. Mitchell.** 1995. Field tests of acoustic devices on groundfish gillnets: Assessment of effectiveness in reducing harbour porpoise by-catch. Pages 349–364 *in* Sensory Systems of Aquatic Mammals. *Edited by* R. A. Kastelein, J. A. Thomas, and P. E. Nachtigall. De Spil Publishers, Woerden, The Netherlands.

Lien, J., M. Morete, N. Brown, P. Hennebury, and **K. Butler.** 1995. An Acoustic Broom? Effects of high amplitude acoustic devices used as seal deterrents on large cetaceans. Abstracts of the Eleventh Biennial Conference on the Biology of Marine Mammals, Marine Mammal Society 69.

Lien J., D. Pittman, C. Hood, C. Richter, D. Borggaard, F. Marques, and **S. Todd.** 1995. Entrapments in fishing gear and strandings in Newfoundland and Labrador reported to the Entrapment Assistance Programme during 1994. A report to the Department of Fisheries and Oceans and the Atlantic Fisheries Adjustment Program. Memorial University of Newfoundland, St. John's, Newfoundland.

Lien, J., D. G. Taylor, and **D. Borggaard.** 1995. Management of underwater explosions in areas of high whale abundance. Proceedings of the International Conference on Technologies for Marine Environment Preservation (MARIEN V '95), Volume 2: 627–632.

Marques, F., and **J. Lien.** 1995. Spatial and temporal patterns of baleen whale habitat use in Placentia Bay, Newfoundland. Abstracts of the Eleventh Biennial Conference on the Biology of Marine Mammals, Marine Mammal Society, 72.

Nachtigall, P. E., J. Lien, W. W. L. Au, and **A. J. Read.** 1995. Harbour porpoises: Laboratory studies to reduce bycatch. De Spil Publishers, Woerden, The Netherlands, 168 pages.

Nelson, D., and **J. Lien.** 1995. Analysis of patterns of incidental entrapments of cetaceans in fixed fishing gear. Proceedings of the World Fisheries Congress.

Todd, S., P. Ostrom, and **J. Lien.** 1995. The use of isotope ratios in foraging studies of humpback whales. Abstracts of the Eleventh Biennial Conference on the Biology of Marine Mammals, Marine Mammal Society, 115.

Todd, S., P. Stevick, J. Lien, F. Marques, and **D. Ketten.** 1995. Behavioral effects of exposure to underwater explosions in humpback whales (*Megaptera novaeangliae*). Canadian Journal of Zoology 74: 1661–1672.

Volgenau, L., S. D. Kraus, and **J. Lien.** 1995. The impact of entanglements on two substocks of the western North Atlantic humpback whale, *Megaptera novaeangliae*. Canadian Journal of Zoology 73: 1689–1698.

Baird, R. W., D. Nelson, J. Lien, and **D. W. Nagorssen.** 1996. The status of the Pygmy Sperm Whale (*Kogia breviceps*) in Canada. Canadian Field-Naturalist 110: 525–532.

Hai, D. J., J. Lien, D. Nelson, and **K. Curren.** 1996. A contribution to the biology of the white-sided dolphin, *Lagenorhychus albirostris*, in waters off Newfoundland. Canadian Field Naturalist 110(2): 278–287.

Hood, C., J. Lien, and **P. Y. Daoust.** 1996. Ocular fluid analysis in harbour porpoise as a potential technique for determining postmortem interval. Bulletin of the Canadian Socociety of Zoologists 27(2): 65.

Lien, J. 1996. Creating protected marine areas in the new ocean. Marine Protected Areas Strategies in British Columbia, Parks Canada, Vancouver, Brirish Columbia.

Lien, J. 1996. A review of present knowledge of collisions with fishing gear and the use of sound to prevent or reduce the entanglement of large cetaceans in fixed fishing nets and traps, and comments on working with fishermen on marine mammal problems: Active acoustic solutions to cetacean by-catch. U.S. Marine Mammal Commission, Washington, D.C.

Lien, J. 1996. Conserving ocean resources: A scrutiny on the Bounty. Ecos 17(1): 16–20.

Lien, J., and **D. Pittman.** 1996. A survey of mussel growers in the Atlantic provinces: Predation by diving ducks on mussel beds. Report to the Atlantic Canada Shellfish Growers and the Canadian Centre for Fisheries Innovation. 10 pages.

Lien, J., S. K. Todd, and **D. Pittman.** 1996. Entrapments in fishing gear and strandings in Newfoundland and Labrador reported to the Entrapment Assistance Program during 1995. Report to the Department of Fisheries and Oceans and the Newfoundland and Labrador Department of Food, Fisheries, and Agriculture. 10 pages.

Nelson, D., and **J. Lien.** 1996. The status of the long-finned pilot whale, *Globicephala melas*, in Canada. Canadian Field-Naturalist 110(3): 511–524.

Nelson, D., and **J. Lien.** 1996. Status report on the long-finned pilot whale *Globicephala melas*. Committee on the Status of Endangered Wildlife in Canada, Ottawa. 46 pages.

Richter, C., and **J. Lien.** 1996. A report to groundfish gillnet fishermen in the Bay of Fundy on the impact of acoustic alarms designed to reduce harbour porpoise by-catches on fish species. Report to the Department of Fisheries and Oceans—Scotia/Fundy and the Fishermen's Association of the Bay of Fundy. 10 pages.

Richter, C. J., J. Lien, and **C. Hood.** 1996. Effectiveness of active, acoustic devices in reducing harbour porpoise by-catch in groundfish gillnets in the Bay of Fundy. Bulletin of the Canadian Society of Zoologists 27(2): 92.

Todd, S. K., P. Ostrom, and **J. Lien.** 1996. Carbon and nitrogen stable isotope ratios suggest potential seasonal and annual diet changes in humpback whales *(Megaptera novaeangliae)*. Bulletin of the Canadian Society of Zoologists 27(2): 101.

Trippel, E. A., M. B. Strong, C. Hood, C. Richter and **J. Lien.** 1996. By-catch of harbour porpoise (*Phocoena phocoena*) in the lower Bay of Fundy gillnet fishery in 1995. Canadian Science Advisory Secretariat, Atlantic Fisheries Research Document 1996/110.

Lien, J. 1997. Foundation fisheries. Report to the Fisheries Resource Conservation Council. 5 pages.

Lien, J., and **P. Hennebury.** 1997. You can fool all of the ducks some of the time; you can fool some of the ducks all of the time; but you can't fool all of the ducks all of the time: An investigation of diving duck predation on farmed mussels, and evaluation of a harassment procedure to minimize it. Report for the Department of Agriculture, Fisheries and Forestry, Government of PEI and the Department of Fisheries, Government of Nova Scotia. 69 pages.

Lien, J., P. Hennebury, and **D. Pittman.** 1997. The use of harassment and acoustic deterrents to minimize predation by diving ducks on mussel farms. Report to the Nova Scotia and Prince Edward Island Departments of Fisheries and the Canadian Centre for Fisheries Innovation. 35 pages.

Lien, J., D. Pittman, and **C. Nordeen.** 1997. An evaluation of effects of high amplitude sounds in the marine environment. Report to the Canadian Centre for Fisheries Innovation, Airmar Corporation, and Fundy Aquaculture. 30 pages.

Palsbøll, P. J., J. Allen, M. Bérubé, P. J. Clapham, T. P. Feddersen, P. S. Hammond, R. R. Hudson, H. Jørgensen, S. Katona, A.H. Larsen, F. Larsen, J. Lien, D. K. Mattila, J. Sigurjónsson, R. Sears, T. Smith, R. Sponer, P. Stevick, and **N. Øien.** 1997. Genetic tagging of humpback whales. Nature 388: 767–769.

Todd, S., P. Ostrom, J. Lien, and **J. Abrajano.** 1997. Use of biopsy samples of humpback whale (*Megaptera novaeangliae)* skin for stable isotope ($\delta^{13}C$) determination. Journal of Northwest Atlantic Fishery Science 22: 71–76.

Curren, K., and **J. Lien.** 1998. Observations of White Whales, *Delphinapterus leucas*, in waters off Newfoundland and Labrador and in the Gulf of St. Lawrence, 1979–1991. Canadian Field-Naturalist 112(1): 28–31.

Daoust, P.-Y., J. Lien, and **A. Knowlton.** 1998. Bowhead whale (*Balaena mysticetus*) stranding on the northeast coast of Newfoundland. Canadian Cooperative Wildlife Health Centre Newsletter Volume 5-3.

Furtado-Neto, M. A. A., C. Monteiro-Neto, A. A. Campos, J. Lien, and **S. M. Carr.** 1998. Are northern-hemisphere humpback whales stranding in South Atlantic beaches? Answers from mitochondrial DNA sequences. Abstract of the VIII Reunião de Trabalho de Especialistas em Mamíferos Aquáticos.

Lien, J. 1998. The Eastport Lobster Conservation Strategy. Sea Wind 14(2): 116–119.

Lien, J. 1998. Social sciences and marine biodiversity conservation. Report to the Social Science and Humanities Research Council. 9 pages.

Lien, J., B. Lane, N. Gribble, and **G. McPherson.** 1998. Use of acoustic alarms to reduce humpback whale and by-catch in shark control gillnets on Queensland's Gold Coast. *In* Shark management and conservation. *Edited by* N. A. Gribble, G. McPherson, and B. Lane. Proceedings from the sharks and man workshop of the Second World Fisheries Congress, Brisbane, Australia, 2 August 1996. Queensland: Department of Primary Industries.

Mackay, D., A. Monsour, and **J. Lien.** 1998. Reproductive status of whales and seals determined by analysis of hormone ratios in biopsies obtained in field studies. President's Research Fund proposal, Memorial University of Newfoundland, St. John's, Newfoundland.

Neto, C. M., and **J. Lien.** 1998. Acoustic devices on gillnets: A viable solution to reduce the mortality of dolphins in Ceara State, Brazil. Report to the Government of Ceara. 6 pages.

Harvey, T., and **J. Lien.** 1998. Prevention of oiled wildlife. Report to the Canadian Coast Guard, Department of Fisheries and Oceans, and Department of the Environment. 36 pages.

Canada Coast Guard. 1999. Prevention of Oiled Wildlife. Report to Minister of Fisheries and Oceans, Transport and Environment, Canadian Coast Guard, St. John's, Newfoundland and Labrador.

Borggaard, D., J. Lien, and **P. Stevick.** 1999. Assessing the effects of industrial activity on large cetaceans in Trinity Bay, Newfoundland (1992–1995). Aquatic Mammals 25(3): 149–161.

Eckert, S. A., and **J. Lien.** 1999. Recommendations for eliminating incidental capture and mortality of Leatherback Turtles (*Dermochelys coriacea*) by commercial fisheries in Trinidad and Tobago. Report to the Wider Caribbean Sea Turtle Conservation Network (WIDECAST). Hubbs-Sea World Research Technical Report Number 2000-310. 7 pages.

Lien, J. 1999. When marine conservation efforts sink: What can be learned from the abandoned effort to examine the feasibility of a National Marine Conservation Area on the NE Coast of Newfoundland? Canadian Council on Ecological Areas (CCEA) 16th Conference, Ottawa, Canada, October 4–6, 1999.

Lien, J. 1999. Lien report: A review of live-capture and captivity of marine mammals in Canada. Department of Fisheries and Oceans, Ottawa, Ontario.

Reeves, R. R., C. Smeenk, C. C. Kinze, R. L. Brownell, and **J. Lien.** 1999. White-beaked Dolphin *Lagenorhynchus albirostris* (Gray, 1846). Pages 1-30 *in* Handbook of Marine Mammals, Volume 6: The Second Book of Dolphins and the Porpoises. *Edited by* S. H. Ridgway and S.R. Harrison. Academic Press, San Diego. Pages 1–30.

Smith, T. D., J. Allen, P. J. Clapham, P. S. Hammond, S. Katona, F. Larsen, J. Lien, D. Mattila, P. J. Palsbøll, J. Sigurjónsson, P. T. Stevick, and **N. Øien.** 1999. An ocean-basin-wide mark-recapture study of the North Atlantic Humpback Whale (*Megaptera Novaeangliae*). Marine Mammal Science 15(1):1–32.

Ledwell, W., J. Huntington, and **J. Lien.** 2000. Whale entrapments in fishing gear and other marine animal incidental entrapments during 2000. Technical report, Habitat Stewardship Program of Environment Canada.

Lien, J. 2000. In the face of disaster — Science for people and nature. Pages 45–53 *in* Coastal Zone Canada '98, Coastal Challenges: Sharing Our Experiences — Building Our Knowledge. *Edited by* J. D. Pringle, C. A. Wright, and M. W. Dunn. Coastal Zone Canada British Columbia Association, Victoria, British Columbia Canada.

Lien, J. 2000. A history of the Entrapment Assistance Programme in Newfoundland and Labrador (1978-2000). Proceedings of the Whales 2000, 7th International Conference of the American Cetacean Society, Monterey, California.

Lien, J. 2000. The conservation basis for the regulation of whale watching in Canada by the Department of Fisheries and Oceans: a precautionary approach. Department of Fisheries and Oceans.

Lien, J., and **M. Dunn.** 2000. Troubled waters: The status of wildlife habitats in Canada's oceans and coasts. Technical Report 5, Wildlife Habitat Canada. 108 pages + appendices.

Lien, J., and **M. Dunn.** 2000. Observations on developing a framework to assess the Department of Fisheries and Oceans' implementation of aquatic habitat management objectives. Report for the Department of Fisheries and Oceans and Wildlife Habitat Canada, Ottawa, Ontario. 28 pages.

Lien, J., and **T. Harvey.** 2000. The Entrapment Assistance Programme: 1999. Report to the Canadian Coast Guard and the Department of Fisheries and Oceans. St. John's, Newfoundland. 13 pages.

Lien, J., and **C. Hood.** 2000. Thoughts on reduction of seabird bycatch in fishing gear based on experiences in mitigation of cetacean bycatch by fisheries: Understanding both animals and fishermen. *In* Workshop on Seabird Incidental Catch in the Waters of Arctic Countries. *Edited by* J. W. Chardine, J. M. Porter, and K. D. Wohl. Conservation of Arctic Flora and Fauna Technical Report Number 7, Iceland.

MacPherson, G., J. Lien, and **N. Gribble.** 2000. An inexpensive alarm to prevent humpback collisions with meshes. *In* Proceedings of Humpbacks – 2000. August 31–3 September, Queensland Museum, Brisbane, Queensland, Australia. Memoirs of the Queensland Museum 47(2).

Corbelli, C., and **J. Lien.** 2001. A preliminary study of the impact of whales watching activity on humpback whales in Witless Bay, Newfoundland. The Osprey 12 00-00

Lien, J. 2001. Whale, shark, and turtle entrapments in fishing gear in Newfoundland and Labrador during 2000. Report to the Department of Fisheries and Oceans. 5 pages.

Lien, J. 2001. Leatherback Turtle bycatch distribution (1979–2000). Report for the Leatherback Turtle Review, Species at Risk Act Secretariat, and the Department of Fisheries and Oceans. 8 pages.

Lein, J. 2001. Harbour Porpoise by-catch in Newfoundland. Report to Harbour Porpoise Review, Species at Risk Act Secretariat, and the Department of Fisheries and Oceans. 12 pages.

Lein, J. 2001. Mitigation of Harbour Porpoise bycatch. Report to Harbour Porpoise Review, Species at Risk Act Secretariat, and the Department of Fisheries and Oceans. 4 pages.

Harris, L., and **J. Lien.** 2001. A review of the White Rose offshore petroleum project. White Rose Public Inquiry, Department of Mines and Energy, Government of Newfoundland and Labrador, St. John's, Newfoundland. 17 pages.

Lien, J. 2001. The conservation basis for the regulation of whale watching in Canada by the Department of Fisheries and Oceans: A precautionary approach. Canadian Technical Report of Fisheries and Aquatic Sciences 2363. 24 pages.

Lien, J. 2001. The growth of the commercial whale watching industry in Canada and a code of conduct for tour boats in Newfoundland and Labrador. The Osprey 12: 10–14.

Lien, J. 2001. Trends in tourism and ecological protection. Pages 20-21 *in* Sustainable Tourism. *Edited by* R. Hingston. Parks Canada, Ottawa, Ontario.

Lien, J., D. Nelson, and **D. J. Hai.** 2001. Status of the White-Beaked Dolphin *Lagenorhynchus albirostris*, in Canada. Canadian Field-Naturalist 115(1): 118–126.

Matilla, D. K., J. Allen, P. J. Clapham, N. Friday, P. S. Hammond, S. Katona, F. Larsen, J. Lien, P. J. Palsboll, J. Robbins, J. Sigurjonsson, T. D. Smith, P. T. Stevick, G. Vikingsson, and **N. Oien.** 2001. Recent findings concerning the migration and breeding ground composition of North Atlantic Humpback whales. *In* Proceedings of Humpbacks – 2000, August 31-3 September Queensland Museum, Brisbane, Queensland, Australia, Memoirs of the Queensland Museum 47 (2)

McPherson, G. R., J. Lien, N. A. Gribble, and **B. Lane.** 2001. Review of an acoustic alarm strategy to minimise bycatch of humpback whales in Queensland coastal gill net fisheries. Memoirs of the Queensland. Museum 47(2): 499-506.

Nordeen, C., and **J. Lien.** 2001. The effects of high amplitude acoustic deterrents on the abundance and distribution of baleen whales (abstract only). Abstracts of the Biennial Meeting of the Marine Mammal Society, Vancouver, British Columbia.

Palsbøll, P. J., J. Allen, T. H. Anderson, M. Bérubé, P. J. Clapham, T. P. Feddersen, N. Friday, P. Hammond, H. Jørgensen, S. K. Katona, A. H. Larsen, F. Larsen, J. Lien, D. K. Mattila, F. B. Nygaard, J. Robbins, R. Sponer, R. Sears, J. Sigurjónsson, T. D. Smith, P. T. Stevick, G. Vikingsson, and **N. Øien.** 2001. Stock structure and composition of the North Atlantic humpback whale, *Megaptera novaeangliae*. Paper SC/53/NAH11 presented to the International Whaling Commission Scientific Committee. Available from IWC, 135 Station Road, Impington, Cambridge, UK.

Ross, B. P., J. Lien, and **R. W. Furness.** 2001. Use of underwater playback to reduce the impact of eiders on mussel farms. ICES Journal of Marine Science, 58: 517–524.

Collins, R. K., and **J. Lien.** 2002. In our own hands: Community-based lobster conservation in Newfoundland (Canada). Biodiversity 3(2): 11–14.

Lien, J., C. Hood, W. Ledwell, and **C. Corbelli.** 2002. More strandings of Sowerby's Beaked Whales on Newfoundland's Northeast Coast. The Osprey 33:1, St. John's, Newfoundland.

Lien, J., H. Whitney, W. Ledwell, P. Y. Daoust, and **B. Sjaer.** 2002. A New Record of a Pigmy Sperm Whale, Kogia breviceps, in Newfoundland. The Osprey 33: 4, St. John's, Newfoundland.

Ledwell, W., J. Huntington, and **J. Lien.** 2002. Whale entrapments in fishing gear and a summary of the Marine Animal Disentanglement Assistance Program in Newfoundland and Labrador during 2002. Report for the Habitat Stewardship Program of Environment Canada. 11 pages.

Lien, J. 2002. *Book review:* Monsters of the Sea: the History, Natural History, and Mythology of the Ocean's Most Fantastic Creatures, and the Search for the Giant Squid. Newfoundland Studies 16(2) 276–279.

Monseur, A., D. McKay, J. Lien, J. Banoube, N. Øien, and **G. Stenson.** 2002. Determination of pregnancy status from blubber samples in Minke Whales (*Balaenoptera acutorostrata*). Marine Mammal Science 18(1): 112–120.

Hood, C., P. Y. Daoust, J. Lien, and **C. Richter.** 2003. An experimental study of postmortem ocular fluid and core temperature analysis in incidentally captured harbour porpoise (*Phocoena phocoena*). North Atlantic Marine Mammal Commission Scientific Publication 5:229–242.

Stenson, G., J. Lien, J. Lawson, and **R. Seton.** 2003. Ice entrapments of Blue Whales in Southwest Newfoundland: 1868–1992. Pages 15-17 *in* Proceedings of the workshop on the development of research priorities for the northwest Atlantic blue whale population, 20-21 November 2002. *Edited by* V. Lesage and M. Hammill. Fisheries and Oceans Canada, Canadian Science Advisory Secretariat, proceeding series 2003/031.

Stevick, P. T., J. Allen, M. Bérubé, P. J. Clapham, S. K. Katona, F. Larsen, J. Lien, D. K. Mattila, P. J. Palsbøll, J. Robbins, J. Sigurjónsson, T. D. Smith, N. Øien, and **P. S. Hammond.** 2003. Segregation of migration by feeding ground origin in North Atlantic humpback whales (*Megaptera novaeangliae*). Journal of Zoology 259(3): 231–237.

Stevick, P. T., J. Allen, P. J. Clapham, N. Friday, S. K. Katona, F. Larsen, J. Lien, D. K. Matilla, P. J. Palsbøll, J. Sigurjónsson, T. D. Smith, N. Øien, and **P. S. Hammond.** 2003. North Atlantic humpback whale abundance and rate of increase four decades after protection from whaling. Marine Ecology Progress Series 258: 263–273.

McPherson, G. R., D. Ballam, J. Stapley, S. Peverell, D. H. Cato, N. Gribble, C. Clague, and **J. Lien.** 2004. Acoustic alarms to reduce marine mammal bycatch from gillnets in Queensland waters: Optimising the alarm type and spacing. Proceedings of Acoustics 2004, November 3–5, 2004, Gold Coast, Australia.

Martins A. M. A., T. T. Alves-Junior, M.A. A. Furtado-Neto, and **J. Lien.** 2004. The most northern record of Gervais' beaked whale, *Mesoplodon europaeus* (Gervais, 1855), for the southern hemisphere. Latin American Journal of Aquatic Mammals 3: 151–155.

Monteiro-Neto, C., F. J. C. A, Vila, T. T. Alves-Jr, D. S. Araüjo, A. A. Campos, A. M. A. Martins, C. L. Parente, A. Manuel, R. Furtado-Neto, and **J. Lien.** 2004. Behavioral responses of *Sotalia fluviatilis* (Cetacea, Delphinidae) to acoustic pingers, Fortaleza, Brazil. Marine Mammal Science 20(1): 145–151.

Ledwell, W., J. Lien, and **D. Wareham.** 2005. A possible ship collision with a Sowerby's beaked whale (*Mesoplodon bidens*) that stranded in Conception Bay, Newfoundland. The Osprey 36: 4

Stevick, P. T., J. Allen, P. J. Clapham, S. K. Katona, F. Larsen, J. Lien, D. K. Mattila, P. J. Palsbøll, R. Sears, J. Sigurjónsson, T. D. Smith, G. Vikingsson, N. Øien, and **P. S. Hammond.** 2006. Population spatial structuring on the feeding grounds in North Atlantic humpback whales (Megaptera novaeangliae). Journal of Zoology 270(2): 244–255.

McAlpine, D., M. C. James, J. Lien, and **S. A. Orchard.** 2007. Status and conservation of marine turtles in Canadian waters. Pages 85-112 *in* Ecology, Conservation and Status of Reptiles in Canada. *Edited by* C. N. L. Seburn and C. A. Bishop. Herpetological Conservation 2. Canadian Amphibian and Reptile Conservation Network, Ottawa.

Lien, J. 2008. Entrapment and Entanglement. Pages 391-392 *in* Encyclopedia of Marine Mammals, Second edition. W. F. Perrin, B. Würsig, and J. G. M. Thewissen. Academic Press, San Diego.

Patents

"Whale Alert", Acoustic deterrent to keep whales out of fishing nets. Patents held with J. Guigne, J. Guzzwell, C-CORE, NewTech in Canada, U.S.A. and Australia.

Books and Guides

Lien, J., (with N. Hennessey). 1982. Whales of Newfoundland and Labrador. M.U.N. Press, St. John's, Newfoundland, 44 pages,

Lien, J., (with others of the Whale Research Group – M.U.N.) 1984. Getting Along: Enrichment Kit Teacher's Guide. Department of Education, Government of Newfoundland and Labrador, St. John's, Newfoundland, 45 pages.

Lien, J., (with others of the Whale Research Group – M.U.N.) 1984. Getting Along: Teacher's Guide. (with others of the Whale Research Group – M.U.N.) Breakwater Books, St. John's, Newfoundland, 88 pages. (Curricula for fifth grade)

Lien, J., L. Fawcett, and **S. Staniforth.** 1985. Wet and Fat: Whales and Seals of Newfoundland and Labrador. Breakwater Books. St. John's, Newfoundland. 136 pages. (2nd printing 1988).

Lien, J., with **R. Graham.** *Editors.* 1985. Marine Parks and Conservation: Challenge and Promise, Volume I: Issues. Harkin Park Book Series Number 10., National and Provincial Parks Association of Canada, Toronto, Ontario, 254 pages.

Lien, J., with **R. Graham**. *Editors.* 1985.Marine Parks and Conservation: Challenge and Promise, Volume II: International Experience. Harkin Park Book Series Number 11. National and Provincial Association of Canada, Toronto, Ontario, 212 pages. 5.

Lien, J., with **H. Walter.** 1987. Life along the edge: Where land and sea interact. Teacher's guide for curricula for Grade 4-6. Parks Canada, Ottawa, 62 pages.

Popular Articles/Educational Materials (since 1985 only)

Conservation of wilderness and wildlife to preserve our traditional way of life. Evening Telegram, St. John's, Newfoundland 7 December 1985.

What's the moose capital of Canada? (with **B. Stirling**) Nature Canada, 15 (2) 8-9, 1986.

Fishermen and whales: getting along. The Whale Watcher, 20 (1), 1986.

1986 Fishery Management Calendar (with **H. Walter, Tamura Goodwin, Judy Au**) Published in full page monthly instalments in the Evening Telegram, St. John's, Newfoundland, 1986.

Fishermen's Calendar: 1987 Robinson-Blackmore, St. John's, Newfoundland.

Book Review on The War Against the Seals: A history of the North American Seal Fishery by Briton Cooper Busch. The Evening Telegram, 21 February 1987, pages lA & A4.

Avalon Marine Guide [with **Frances Barry**) Published by Bird Island Charters and the Canadian Park Service, 1988.

Search the Sea: Evaluating a marine display for children (with **J. Dodd**) Eau Canada 4 (1) 3-12, 1987.

A whale of a tale: Following the sea and whalers no more (with **N. Bose**) Evening Telegram, 6 February 1988.

Establishing Marine Parks: New efforts in public education and information programs, Park News. 1988.

The future of Oceans: A review. Evening Telegram, 20 February 1988.

Fisherman's Calendar: 1988 Robinson-Blackmore, St. John's, Newfoundland.

Fisherman's Calendar: 1989 Robinson-Blackmore, St. John's, Newfounland.

Lien, J. 1989. A junk food diet for sperm whales! Atlantic Fishermen, pages ?.

Lien, J., F. Chopin, and **J. Huntington**. 1989. Relict fishing gear effects whales. Fishing News International, August, 57.

Lien, J. 1989. The big whales are in big trouble. Outdoor Canada, Summer, page 20.

Lien J., and **W. Ledwell.** 1989. Continued development of the first North American colony of Manx Shearwaters. The Osprey, 94-95.

Wright, D., and **J. Lien.** 1989. Whales of the Gulf of St. Lawrence and Quebec. Poster published by the Linnean Society, Montreal.

Lien, J., G. B. Stenson, and **G. Goff.**1989. Marine Turtle Education Programs. Marine Turtle Newsletter 45: 3-5.

Lien, J., G. B. Stenson, and **G. Goff.** 1989 Working With Fishermen in the Northwest Atlantic. Marine Turtle Newsletter 5: 13–15.

Identification Guides to whales, seals, birds and sharks. [with **Dawn Nelson**]. Published jointly by Canadian Wildlife Service, Fisheries and Oceans and Memorial University of Newfoundland.

Whales and Seals of Newfoundland and Labrador. [with **D. Nelson**]. Memorial University of Newfoundland, St. John's, Newfoundland.

Fisherman's Calendar: 1991, Fisheries and Oceans, St. John's, Newfoundland.

Fisheries Calendar – 1992, Fisheries and Oceans, St. John's, Newfoundland.

A Teacher's Guide to the 1992 Fisheries Calendar, (with **D. Nelson**) Memorial University of Newfoundland, St. John's, Newfoundland

Marine Fact Sheet Series, Memorial University of Newfoundland and Department of Fisheries and Oceans (Canada), St. John's, Newfounland.

Fisheries Calendar – 1993, Fisheries and Oceans, St. John's, Newfoundland.

Whale Fact Sheets [with **D. Nelson**)] Memorial University of Newfoundland, St. John's

Lien, J. 1993. On the urgent need to protect oceans. World Wildlife Fund Newsletter, Invited editorial.

Lien, J. 1993. The Fisheries Resource Conservation Council. Beyond the Banks, 1 (3), 2-3.

Lien, J. 1994. Fishermen as environmental refugees. Eco 2 (87), 3-4.

Fisheries Calendar – 1994, Fisheries and Oceans, St. John's, Newfoundland.

What difference do you make? Marine Adventures Association Newsletter, 149 New Gower Street, St. John's, Newfoundland.

Lien, J. 1998. The National Marine Conservation Area Feasibility Study. Evening Telegram

Lien, J., B. Chubs, J. Squires, and **A. Hart.** 1999 Conservation Calendar.

Lien, J. 1999. Kill a seal for Jesus – A comment on John Efford's campaign. Evening Telegram. St, John's, Newfoundland.

Series of posters including Whales of Newfoundland, Seals of Newfoundland and Labrador, The Basking Shark and Sharks of Newfoundland, Seabirds of Newfoundland, Common Inshore Fishing Gear, The Capelin, Common Whales of Newfoundland and Labrador, Whale Tails of Newfoundland and Labrador. Educational series with **Don Wright.** [To 1989 over 500,000 published and distributed through Fisheries and Oceans and The Newfoundland and Labrador Department of Education. To 1999 over one million had been published].

[Lien, J.] Monthly column in *Portugal Cove/St. Phillips Times* under pseudonym **"Gammel Ost"**.

Index to Volume 124

Compiled by Leslie Cody

Index to Book Reviews

Botany

Environment

Miscellaneous

Zoology

Electronic Systems: Web Sites

Mailing date of the previous issue 124(3): 25 July 2011

New Editor for *The Canadian Field-Naturalist*

Beginning with 125(1) January–March 2011 issue, Dr. Carolyn Callaghan will edit *The Canadian Field-Naturalist* replacing the retiring Dr. Francis R. Cook, Editor, 1962–1966; 1981–2010.

Carolyn's team will remain the same with some additions to be noted in the next issue.

Submit manuscripts for consideration to: Carolyn Callaghan <editor@canadianfieldnaturalist.ca>

THE CANADIAN FIELD-NATURALIST Volume 124, Number 4 201

Articles

News and Comment

Tributes

(continued on inside back cover

ISSN 0008-3550